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THE RED SPRUCE: ITS GROWTH AND MANAGEMENT

By

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INTRODUCTION.

Spruce is one of the most important woods in the Eastern United States. It grows on large areas in pure or nearly pure stands, is distributed over many of the Northern States, and extends into the southern Appalachians at the higher altitudes. It is used more than any other wood in the manufacture of paper, and supplies a large amount of lumber and other material.

Various methods of forest management for spruce have been adopted by large lumber and pulp companies, of which spruce often forms the principal cut. The chief purpose of this bulletin is to formulate definite systems of forest management for various conditions.[1]

USES OF SPRUCE.

Early in the history of the first New England settlement spruce became established as a valuable wood in shipbuilding, for framing, topmasts, and yards; and, where oak became scarce in the vicinity of the northern shipyards, it was used for ship knees. It soon found its way also into the export trade and was sent to the shipyards of

[1] The author's field investigations had to do chiefly with the spruce as it occurs in second growth. Accordingly, except for a reproduction study made in connection with the remeasurement of spruce permanent sample plots, the data and discussions concerning old growth or virgin conditions are based largely on an office study (1) of the material available in publications, of which the most important are the Adirondack Spruce, by Gifford Pinchot, Practical Forestry in the Adirondacks, by Henry S. Graves (Bulletin 26, Division of Forestry, U. S. Department of Agriculture), and the various annual forestry reports of Maine, New Hampshire, and New York, and (2) of the various unpublished data on spruce which have been collected by members of the Forest Service in times past.

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England, the Continent of Europe, and the West Indies, where it was classed as a construction timber. Not until considerably later, however, did it assume a place of importance in the general market for carpentry and building use. When the supply of virgin white pine in New England declined, spruce was turned to as a substitute. Since 1840 the use of spruce as a lumber wood has steadily increased both in the domestic and foreign markets. Its rise as a raw material in the production of paper dates from about 1870 to 1875, although it was not until 1890 or 1895 that its consumption for this purpose became very important.

The most extensive single use to which spruce is put now is the making of paper, news stock, principally. Fully half the annual cut of red spruce is consumed by the paper industry.

Spruce is widely used in building and rough construction work, particularly where it is not exposed to the weather. In floors it wears better than white pine, but is inferior to many of the hardwoods. It retains its natural color when finished better than white pine, and it takes paint well. As interior finish it is employed for stair work, ceiling, and door, sash, and casing material. It also is made into shingles, siding, and laths, but as shingle material is considered inferior to many other woods. Large quantities are cut into joists, large dimension stuff, and car stock, since for its weight it is one of the strongest woods on the market. After being given preservative treatment to hinder decay it is employed for wharf and bridge piles, railroad ties, posts, and poles.

On account of the resonant quality of the wood, its even structure, the absence of vessels, the extremely fine and regularly distributed medullary rays, and the straight and long fibers spruce is generally considered to be the best wood for piano sounding boards, as well as for wooden musical instruments generally. For this purpose the wood must be of selected quality. It must be straight fibered and free from knots, and must have narrow and uniform rings and but little resin.

Spruce belongs to the class of tasteless woods, and for that reason is extensively used for containers in which articles of food are packed or handled, such as tubs, firkins, butterworkers, churns, fish barrels, and boxes and crates for vegetables and fruit. It is likewise in demand for boxes in which cans and bottles of salad and other table oils are packed for shipment.

Recently spruce has come into general use in the manufacture of airplanes. The wood meets satisfactorily the requirements of this industry, which demands lightness combined with strength and, above all, reliability, including freedom from hidden defects. It is used both for the upright posts and the general framework.

Minor uses of spruce are for matches, toys, clothespins, woodenware, sieve frames, cheese molds, and bandboxes. On account of its straight grain and light weight it finds a considerable use also in the manufacture of ladders, screen frames, cold-storage plants, refrigerators, pump stocks, furniture, canoe paddles, and light boat oars.

Two by-products of spruce may be mentioned. The resinous exudations are used as chewing-gum, and the claim is sometimes made that they possess medicinal properties. The extract made from the tender tips of the branches by boiling with water forms the basis of spruce beer, a nonalcoholic beverage formerly very popular, particularly among seafaring men, by whom it was considered a preventive of scurvy.

AMOUNT AND VALUE OF SPRUCE CUT AND IMPORTED.

Table 1 shows for the year 1909 [1] the amount of spruce of all species utilized for different purposes, and the total and unit value of the material for each use. More than three-fourths of the total was red spruce.

Spruce ranked sixth in 1909 in the amount of lumber produced and contributed 3.9 per cent of the total for all woods. It was surpassed by yellow pine, Douglas fir, oak, white pine, and hemlock. In pulp production it ranked first and supplied 60 per cent of all the wood used. Nearly one-third of this, however, was imported. Spruce ranked ninth in slack stave production (3.6 per cent); twelfth in slack heading production (1.3 per cent); and ninth in the production of slack hoops (0.03 per cent), being surpassed in all of these minor uses by red gum, pine, beech, elm, birch, basswood, and maple. One per cent of the veneers produced in 1909 were of spruce, which ranked fourteenth among the species. In addition, 1 per cent of all the shingles, 0.2 per cent of all the railroad ties, 0.3 per cent of all the telegraph and telephone poles, and 2 per cent of all the cross arms produced in the United States were of spruce.

[1] Forest Products of the United States, 1909, Bureau of the Census in Cooperation with the Forest Service. Government Printing Office, 1911. This contains the latest complete enumeration covering minor as well as major forest products, which accounts for its use here in place of more recent data covering but a part of the field.

TABLE 1.—*Quantity of spruce [1] used in the United States, by States and by classes of uses: 1909.*

State.	Lumber produced.		Pulpwood consumed.				Slack cooperage produced.						Veneers consumed.		Total domestic spruce used. [2]		Grand total. [3]	
			Domestic.		Imported.		Staves.		Headings.		Hoops.							
	Amount	Per cent.	Amount.	Per cent.	Amount.	Per cent.	Amount.	Per cent.	Amount.	Per cent.	Amount.	Per cent.	Amount.	Per cent.	Amount.	Per cent.	Amount.	Per cent.
	1,000 bd. ft.		*Cords.*		*Cords.*		*1,000 pieces.*		*1,000 sets.*		*1,000 pieces.*		*1,000 bd. ft.*		*1,000 bd. ft.*		*1,000 bd. ft.*	
1 Maine	421,297	24.1	552,032	33.4	166,500	21.6	46,538	64.5	976	52.5	.....	.....	500	12.2	715,277	27.4	798,527	26.7
2 New Hampshire	253,107	14.5	188,229	11.4	106,625	13.9	(*)	(*)	.....	.....	106	100	.....	.....	347,257	13.3	400,569	13.4
3 Vermont	123,164	7.0	(*)	(*)	(*)	(*)	15,441	21.4	621	33.4	.....	.....	.....	.....	129,553	5.0	129,553	4.3
4 Massachusetts	36,911	2.1	15,827	1.0	13,529	1.8	863	1.2	10	0.5	.....	.....	.....	.....	45,133	1.7	51,898	1.7
5 Rhode Island	355	(*)	.....	.....	.....	.....	(*)	(*)	.....	.....	.....	.....	.....	.....	355	(*)	355	(*)
6 Connecticut	262	(*)	.....	.....	.....	.....	(*)	(*)	.....	.....	.....	.....	.....	.....	262	.....	262	(*)
7 New York	127,864	7.3	384,883	23.3	408,719	53.2	635	0.9	4	0.2	.....	.....	100	2.4	320,626	12.3	524,985	17.6
8 New Jersey	125	(*)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	125	(*)	125	(*)
9 Pennsylvania	7,307	(*)	16,732	1.0	19,894	2.6	360	0.5	.....	.....	.....	.....	.....	.....	15,793	.6	25,740	0.9
10 Delaware	1,610	(*)	(*)	(*)	(*)	(*)	.....	.....	(*)	(*)	.....	.....	.....	.....	1,610	.1	1,610	(*)
11 Maryland	5,718	(*)	(*)	(*)	(*)	(*)	.....	.....	.....	.....	.....	.....	.....	.....	5,718	.2	5,718	0.2
12 Virginia	79,672	4.6	46,089	2.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	102,716	3.9	102,716	3.4
13 West Virginia	242,897	13.9	31,399	1.9	.....	.....	(*)	(*)	.....	.....	.....	.....	.....	.....	258,596	9.9	258,596	8.7
14 North Carolina	24,277	1.4	30,000	1.8	.....	.....	.....	.....	.....	.....	.....	.....	10	0.2	39,237	1.5	39,287	1.3
15 South Carolina	13,803	0.8	(*)	(*)	(*)	(*)	.....	.....	(*)	(*)	.....	.....	.....	.....	13,803	.5	13,803	0.5
16 Georgia	2,789	(*)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2,789	.1	2,789	0.1
17 Kentucky	2,226	(*)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2,226	.1	2,226	0.1
18 Tennessee	720	(*)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	720	(*)	720	(*)
19 Ohio	78	(*)	5,000	0.3	9,131	1.2	.....	.....	.....	.....	.....	.....	20	0.5	2,598	.1	7,164	0.2
20 Wisconsin	21,168	1.2	(*)	(*)	(*)	(*)	.....	.....	.....	.....	.....	.....	.....	.....	21,168	.8	21,168	0.7
21 Michigan	21,797	1.2	12,459	0.7	17,470	2.3	170	0.2	.....	.....	.....	.....	.....	.....	28,083	1.1	36,818	1.2
22 Minnesota	78,500	4.5	47,223	2.9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	102,112	3.9	102,112	3.4
23 Montana	6,837	(*)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6,837	.3	6,837	0.2
24 Wyoming	675	(*)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	675	(*)	675	(*)
25 Idaho	1,136	(*)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1,136	(*)	1,136	(*)
26 Utah	2,381	(*)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2,381	.1	2,381	0.1
27 Colorado	32,471	1.9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	32,471	1.2	32,471	1.1
28 Arizona	4	(*)	.....	.....	.....	.....	(*)	(*)	(*)	(*)	.....	.....	.....	.....	4	(*)	4	(*)
29 New Mexico	3,822	(*)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3,822	.1	3,822	0.1
30 Washington	165,331	9.4	(*)	(*)	(*)	(*)	5,661	7.8	131	7.0	.....	.....	2,239	54.5	169,721	6.5	169,721	5.7

31 Oregon	57,002	3.3	32,340	2.0	.....	.....	(*)	(*)	(*)	(*)	.....	.....	1,200	29.2	74,372	2.9	74,372	2.5
32 California	13,241	0.8	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	.....	.....	42	1.0	13,283	.5	13,283	0.5
All other	.....	2.0	291,036	17.5	26,464	3.4	2,551	3.5	119	6.4	.....	.....	.....	.....	146,604	5.9	159,836	5.4
United States	1,748,547	100.0	1,653,249	100.0	768,332	100.0	72,219	100.0	1,861	100.0	106	100	4,111	100.0	2,607,113	100.0	2,991,279	100.0
Equivalent in thousand board feet	1,748,547	.....	826,625	.....	384,166	.....	24,073	.....	3,722	.....	35	.....	4,111	.....	.....	.....	.....	.....
Per cent of total	58.5	.....	27.6	.....	12.9	.....	0.8	.....	0.1	.....	0.001	.....	0.1	.....	87.1	.....	100.0	.....
Total value	$29,561,315	.....	$15,400,341	.....	$8,715,892	.....	$398,260	.....	$80,200	.....	$742	.....	$55,662	.....	$45,496,520	.....	$54,212,412	.....
Per cent of total value	54.6	.....	28.4	.....	16.1	.....	0.7	.....	0.1	.....	0.001	.....	0.1	.....	83.9	.....	100.0	.....
Average value per thousand board feet	$16.91	.....	$18.64	.....	$22.70	.....	$16.54	.....	$21.52	.....	$21.20	.....	$13.54	.....	$17.45	.....	$18.13	.....

[1] The approximate distribution of the cut of spruce by species is as follows: Red spruce (*Picea rubens*) dominates in the first 19 States enumerated, with an aggregate consumption of 2,366,643,000 board feet, representing 79.1 per cent of the amount tabulated. In northern Maine and New Hampshire there is an appreciable amount of white spruce (*Picea canadensis*) in mixture. Black spruce (*Picea mariana*) may also be found sparingly represented in the figures for the New England and North Atlantic States. White spruce dominates commercially in the Lake States (Nos. 20–22, inclusive), with an aggregate cut of 160,098,000 board feet (5.3 per cent), although the black spruce is an important factor in many localities. Engelmann spruce (*Picea engelmanni*) dominates commercially in the Rocky Mountain group of States (Nos. 23–29, inclusive), where the consumption aggregates 47,326,000 board feet (1.6 per cent). A small amount of white spruce doubtless enters into the figures for Montana, while the Colorado blue spruce (*Picea parryana*) is doubtless reported in the figures of the other States. Sitka spruce (*Picea sitchensis*) dominates commercially in Washington, Oregon, and California, where the spruce cut aggregates 257,178,000 board feet (8.6 per cent), though Engelmann spruce is doubtless cut to a small extent along the eastern borders of these States.

[2] In addition to the above there were produced during 1909, 147,132,000 spruce shingles (equivalent to 14,713,000 board feet), 225,000 spruce ties (7,500,000 board feet), 11,423 telephone poles (685,000 board feet), and 74,463 telephone cross arms (298,000 board feet); in the aggregate 23,196,000 board feet.

[3] The equivalents used in reducing other units of measure to thousands of board feet are as follows: 2 cords, 3,000 staves, 500 sets of headings, 3,000 hoops, each equal 1,000 board feet.

* Values too small to show separately; combined and included in "All other."

According to the census,[1] the reported production of spruce lumber remained practically stationary during the 10 years prior to 1909. The cut of 1909 was only slightly greater than that of 1907, and had the 1907 canvass been as complete it is probable that the 1907 production would have been found the greater, which indicates that the production of spruce lumber had then already passed its maximum. This assumption is borne out by subsequent figures, since in 1910 there were but 1,449,912,000 board feet produced, in 1913 but 1,046,816,000 board feet, in 1914 but 1,245,614,000 board feet, and in 1916 but 1,129,750,000 board feet.

In the consumption for pulp in 1907 spruce showed a decline in amount and in proportion to the other woods used. In 1910 there was a still further decline, followed by a slight recovery in 1911 to not quite so much as was consumed in 1909. In 1914 there was an increase over 1909 spruce pulpwood consumption of approximately 10 per cent with a total of 2,665,974 cords of which 1,957,487 cords was domestic spruce. By 1916 this gain amounted to approximately 30 per cent with a total of 3,143,793 cords of which 2,399,993 cords was domestic spruce. In both years the consumption of imported spruce was below that in 1909, which had to be made good by the domestic spruce supply. This was done at the expense of spruce lumber production which in 1909 made up 63 per cent of the combined total of pulp and lumber supplied by domestic spruce which in 1914 was but 56 per cent and in 1916 only 48 per cent. Notwithstanding this material increase in consumption of spruce for pulp the combined total of pulp and lumber supplied by domestic spruce decreased from 2,575,172,000 board feet in 1909 to 2,224,358,000 board feet in 1914 and 2,329,747,000 board feet in 1916. It is very evident that spruce lumber production was curtailed and a larger percentage of this high-grade material put into pulp notwithstanding that during the last two years European buyers of American forest products have increased their orders for spruce for all purposes abroad. Its accessibility in the east and its general all-round properties, including lightness, have made it much in demand.

In the use of spruce for slack cooperage and veneers in 1909 there was also a decrease, while in the number of railroad ties there was an increase due to the increasing use of chemical preservatives which made the less durable woods, such as spruce, more largely available for this purpose.

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[1] Forest Products of the United States, 1909, Bureau of the Census in Cooperation with the Forest Service, Government Printing Office, 1911. This contains the latest complete enumeration covering minor as well as major forest products, which accounts for its use here in place of more recent data covering but a part of the field.

PRESENT STAND OF SPRUCE.

The amount of standing spruce timber in the United States,[1] according to recently revised estimates, is 116,500 million feet board measure, or 4 per cent of the total standing timber of all kinds. This stand is divided among the three commercial spruce regions as follows: The eastern or red spruce region, 48.3 per cent;[2] the Rocky Mountain or Engelmann spruce region, 30.3 per cent; and, the Pacific coast or Sitka spruce region, 21.4 per cent.

The commercial stands of spruce timber in the eastern spruce region by States are given in Table 2.

TABLE 2.—*Stand of spruce in the eastern or red spruce region.*

State.	Billions of board feet.	Per cent.
Maine	26.0	46.2
New Hampshire	5.9	10.5
Vermont	1.4	2.5
Massachusetts	0.9	1.6
New York	13.3	23.6
Maryland	0.2	0.3
West Virginia	8.6	15.3
Total	56.3	100.0

VALUE OF SPRUCE AND SPRUCE STUMPAGE.

In total value of annual lumber production in 1909 spruce stood sixth among the woods, with 4.3 per cent of the gross output, and in unit value of the manufactured product it stood fifteenth, with a value of $16.91 per 1,000 board feet. It was surpassed in total value by yellow pine, oak, white pine, Douglas fir, and hemlock; and in unit value by walnut, cherry, hickory, yellow poplar, ash, oak, cypress, cedar, basswood, white pine, sugar pine, cottonwood, elm, and birch.

Table 3 shows the value of spruce stumpage by States, based both on estimates and on reports of sales collected by the Forest Service for the years 1907 and 1912. As a means of comparison the table includes the values for spruce in the Lake States, Rocky Mountain, and Pacific Coast States for these same years; also the census figures for all spruce for the years 1899 and 1904.

The range of 1912 values was from $1 to $11 per thousand, according to estimates, and from $2 to $11, according to sales. The minimum estimated value, $1, was reported from North Carolina; and

[1] Unpublished estimates of the "Standing Timber in the United States," prepared by the Section of Computing, Forest Service, February, 1915.

[2] The amount of spruce of commercial size remaining in the Lake States was apparently too small to be expressed in terms of billion feet. This is doubtless also true of other States, as those in the southern Appalachians, omitted from Table 2.

the maximum from New York. North Carolina, Tennessee, and Virginia each reported $2 sales, and New York reported maximum price sales, $11.

In seven of the red spruce States, Maine, New Hampshire, Vermont, New York, Maryland, North Carolina, and Kentucky, there was a rise in stumpage values from 1907 to 1912, while in the remainder there was a decline. Leaving out of consideration Maryland and Kentucky, where the number of reports is too small to form a reliable basis, the greatest rise took place in New York and showed a gain of 25 per cent and 35 per cent on the basis of estimates and of sales, respectively. The next greatest gain was in North Carolina, where a rise of 21 per cent is indicated on the basis of 16 estimates. Vermont ranks third in percentage of increase; New Hampshire, fourth; and Maine, with the largest number of reports, shows the least increase in values, 6 per cent according to estimates and 3 per cent according to sales. New York also ranks first in the greatest actual increase, namely, $1.44 and $2, according to estimates and to sales, respectively, followed by Vermont, New Hampshire, North Carolina, and Maine, in the order named.

TABLE 3.—*Stumpage values of spruce.*[1]

ALL SPECIES OF SPRUCE.[2]

State.	1912				1907	
	Average per 1,000 feet from estimates.		Average per 1,000 feet from sales.		Average per 1,000 feet.	
	Value per 1,000 board feet.	Number of reports.	Value per 1,000 board feet.	Number of reports.	Value per 1,000 board feet.	Number of reports.
All States reporting	$4.54	488	$4.16	175	$4.35	383
EASTERN (RED) SPRUCE.						
All Eastern States	$6.11	236	$5.90	78	$5.53	164
All Northeastern States	6.50	205	6.32	70	5.93	114
Maine	6.09	102	5.93	37	5.74	34
New Hampshire	6.78	28	6.54	13	6.07	21
Vermont	6.82	25	6.72	9	5.87	31
Massachusetts	6.50	14	5.00	3	7.07	7
New York	7.25	36	7.81	8	5.81	21
All Appalachian States	3.51	31	2.15	8	4.62	50
Pennsylvania	6.37	4	.....	.....	8.00	12
Maryland	4.50	3	.....	.....	3.33	3
Virginia	3.00	3	2.00	1	3.61	9
West Virginia	4.17	3	.....	.....	4.63	15
North Carolina	2.52	16	2.33	6	2.08	6
Kentucky	6.00	1	.....	.....	1.63	2
Tennessee	2.00	1	2.00	1	2.50	3

[1] The values per cord for pulpwood may be roughly approximated by halving those given in the table, although the common practice in the northern spruce country is to figure a cord equivalent to 600 board feet.

[2] The census gave the average values of spruce stumpage for all States as $3.70 per 1,000 feet in 1904 and $2.26 per 1,000 feet in 1899.

TABLE 3.—*Stumpage values of spruce*—Continued.

LAKE STATES (WHITE) SPRUCE.

State.	1912				1907	
	Average per 1,000 feet from estimates.		Average per 1,000 feet from sales.		Average per 1,000 feet.	
	Value per 1,000 board feet.	Number of reports.	Value per 1,000 board feet.	Number of reports.	Value per 1,000 board feet.	Number of reports.
All Lake States	$4.68	94	$4.59	20	$5.60	99
Wisconsin	4.63	38	4.67	9	6.16	37
Michigan	5.04	29	4.79	6	5.21	47
Minnesota	4.36	27	4.20	5	5.47	15

ROCKY MOUNTAIN (ENGELMANN) SPRUCE.

All Rocky Mountain States	$2.12	78	$2.37	51	$1.87	52
Montana	2.07	21	2.13	11	1.83	8
Wyoming	2.28	8	2.47	8	2.00	2
Idaho	1.71	14	2.41	6	1.73	11
Utah	2.15	5	2.30	7	1.64	7
Colorado	2.31	25	2.45	14	2.00	22
Arizona	2.00	2	2.00	1	.....	.....
New Mexico	2.50	3	2.67	3	1.94	2
Nevada	.....	.....	3.00	1	.....	.....

PACIFIC COAST (SITKA) SPRUCE.

All Pacific States	$2.10	80	$2.10	26	$1.58	68
Washington	2.26	52	2.41	16	1.73	46
Oregon	1.90	20	1.54	8	1.40	14
California	1.56	8	1.87	2	1.03	4

The number of reports from the remaining five Eastern or red spruce States which show a shrinkage in values is entirely inadequate for a reliable estimate of stumpage price tendencies. It is possible, however, that in such States as Massachusetts and Pennsylvania, where the amount of spruce was never extensive and where cutting has been going on for many years, there is in fact an actual decline in values due to the poor quality of timber now available for cutting. This also may be the situation in Maryland, Virginia, and Kentucky. In West Virginia, North Carolina, and Tennessee, however, the apparent decline is doubtless due to an insufficient number of reports, since the virgin spruce growth in these States is of choice quality, and much of it is in localities which are just now being developed.

Eastern spruce in 1912 showed the second highest average stumpage value of 20 softwoods and the ninth highest of 38 softwoods and hardwoods combined.[1] It was exceeded in value by cherry ($16.25), walnut ($15.64), pine ($8.35), ash ($7.87), yellow poplar ($7.87), hickory ($7.82), basswood ($7.70), and oak ($7.28).

[1] Compiled from estimates on all species reported in 1912.

Too much dependence can not be placed on any of these values except for the purposes of general comparison, for the reason that through a process of adulteration of the purity of the product, so to speak, the true rise in value for a period of years is not shown by average stumpage price quotations. To illustrate: The average stumpage values per 1,000 feet in a certain locality might have been $2 twenty years ago, $3 ten years ago, and $4 to-day, while the quality of the cut in those years might have been 100 per cent first quality 20 years ago, worth $2 per 1,000 feet, 67 per cent first quality 10 years ago, worth $4, and 40 per cent first quality to-day, worth $8, the differences being made up in the latter instances by cheap, low-grade material which 20 years ago could not have been given away. Thus the true rise in stumpage value, instead of being from $2 to $4, as indicated by the average stumpage figures, should be $2 to $8, based on the same class of product throughout the period. This is but one of many similar conditions which help to obscure the true rise which has taken place and is taking place not only with spruce but with all stumpage and which must be understood in making use of any general stumpage figures.

RANGE AND DISTRIBUTION.

Regarding the range and distribution of red spruce, the various botanical authorities are in disagreement. This condition arises largely from the fact that the red spruce and the closely allied black spruce are not perfectly distinguishable under some circumstances. When red spruce is segregated from the black spruce, its range is given as from Prince Edwards Island to the valley of the St. Lawrence River, southward to the coast of Massachusetts, along the interior hilly parts of New England and New York to the Allegheny Mountains, to western North Carolina, eastern Tennessee, and the higher peaks of South Carolina. When the black and red spruce are considered as a single species, the range extends, in addition to the above, from Labrador and Newfoundland to the valley of the McKenzie River in latitude about 65° north and, crossing the Rocky Mountains, from the interior of Alaska to the valley of the White River and from the eastern foothills of the Rocky Mountains in Alberta through northern Saskatchewan and northern Manitoba to central Wisconsin and Michigan. The accompanying map (fig. 1) shows these ranges graphically as well as those for the other species of this genus which are indigenous to the United States.

The red spruce occurs chiefly on well-drained uplands and mountain slopes. In the northern portion of its range it is found on the better-drained soils at or near sea level. Within the United States its commercial range is rarely below 1,000 feet elevation, although under some conditions it may extend somewhat lower, as, for instance, in swamps. In these situations the red and black spruce find their

common meeting ground and approach each other so nearly in character of growth and appearance that it is difficult to determine at what point the one entirely supersedes the other. Red spruce is also found in small groves along the seacoast of southern Maine and northern Massachusetts. Spruce, presumably red spruce, is to be found in small parcels at between 200 and 500 feet elevation on the low rolling uplands of eastern Maine, where it has taken possession of old abandoned pastures.

The upper limit of its range within the United States is at timber line, although in the Northeastern States its commercial limit may

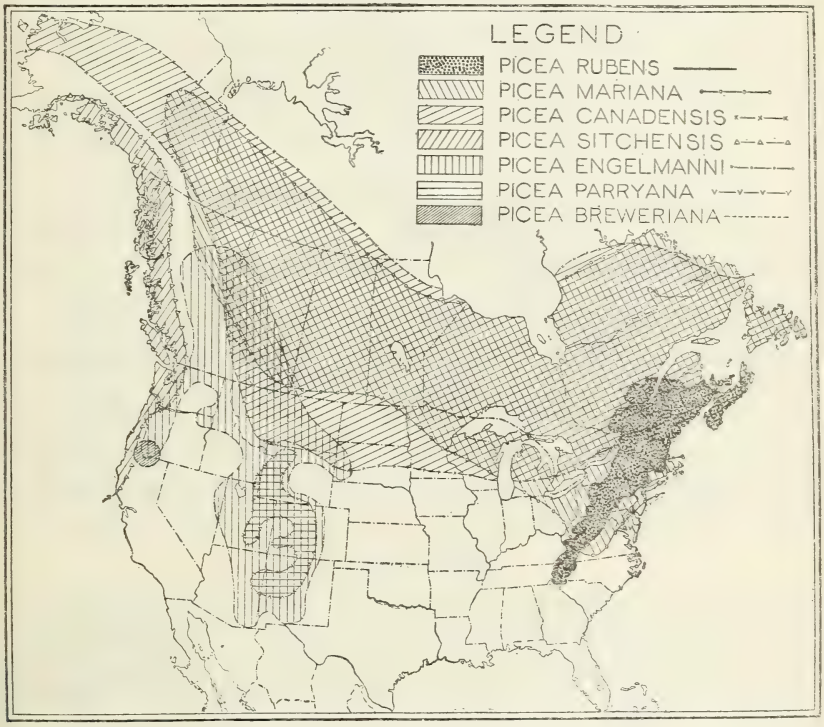

FIG. 1.—The botanical range of spruce.

be set at about 4,000 feet above sea level. In Maryland its minimum altitudinal range is 2,500 feet above sea level and constantly rises toward the southern limits of its occurrence in northern Georgia. It probably reaches its commercial upper limit between 5,000 and 6,000 feet in the mountains of North Carolina and Tennessee.

FOREST TYPES.

The old growth forests of the spruce region may be divided into four main types. The names chosen here for these types are those commonly used by lumbermen in describing them according to the various situations on which they occur.

The relative importance of the four types varies according to the locality. In the mountainous portions of central Maine the mixed hardwood lands and spruce slopes are of greatest importance, while in the northern part of the State the spruce flat is the more prevalent. The spruce slope is the characteristic type in the White Mountain region. In the Adirondacks the mixed hardwood type is the most common, followed by the spruce swamp and the spruce slope. In the southern portion of its range spruce is only sparingly associated with hardwoods, the spruce slope type being more prevalent.

SPRUCE SWAMPS.

The spruce swamp type dominates the low-lying, poorly-drained areas, whose soil is a muck or peat, spongy in texture, and acid. The characteristic species are red spruce, black spruce, balsam, tamarack, cedar, soft maples, black ash, and other moisture-loving trees. Sphagnum moss and low water-loving herbaceous plants commonly form the undergrowth. Spruce usually makes a slow growth in such situations, and is short and scraggly in appearance. It is particularly susceptible to windthrow on these soils, which prevents its attaining as large size or as great age as when growing on the better types of soil. Even-aged stands are not at all uncommon. Numerous small islands of drier and firmer soil texture are scattered throughout this type of soil. They support a somewhat better growth of spruce, mixed with hemlock, white pine, birch, and some beech and sugar maple. Balsam, tamarack, or arborvitæ will not infrequently be found predominating in the wetter portions; and black spruce is largely confined to such places.

SPRUCE FLATS.

The level and rolling flats bordering the swamps, lakes, and watercourses, are occupied by the spruce flat type. The soil is variable in composition, moderately deep where sandy or gravelly in texture, and shallow where stones and bowlders predominate. While the percentage of moisture may be high, the drainage is free and a favorable condition is afforded for thrifty tree development. The flat type is in large measure a transition between the swamp type and the type of the mixed hardwood lands, and in many respects exhibits the characteristics of each. Spruce, birch, soft maples, white pine, hemlock, and balsam are the characteristics trees in mixture. The presence of black ash, which is usually accompanied by considerable balsam, denotes conditions bordering on the swamp type. The presence of sugar maple, on the other hand, denotes a transition to the hardwood lands. White pine of good quality formerly occurred in abundance in this type in both Maine and the Adirondacks, particularly where a sandy soil predominated. Spruce attains an inter-

mediate development here, while birch and the better hardwoods are inferior in development as compared with the same species growing on the hardwood lands. Hemlock and red maple find the best conditions for their development in this type. Windfall is not uncommon, and as a result young even-aged stands of spruce are found occupying the ground where this has taken place. Second-growth stands of birch and red maple may also be found occupying such areas.

MIXED HARDWOOD LANDS.

The mixed hardwood type occupies the best soil sites of the region, usually the benches and the lower mountain slopes. The soil is here best adapted to hardwood growth, is deep, of more or less even texture, fresh, and well-drained. Besides spruce, sugar maple, beech, and birch predominate, and there is a scattering of hemlock, white pine, soft maple, cherry, and a variety of other species. The proportion of spruce in mixture depends on topographic conditions. On gentle slopes, broad benches, and low ridges the hardwoods find conditions so favorable to their development that the spruce is largely crowded out. The more irregular and broken topography enables the spruce to compete with the hardwoods on more nearly equal terms. What spruce lacks in reproductive power it makes up by its superior ability to grow on the rougher, thinner soils. The broken topography undoubtedly favors spruce on account of the higher percentage of moisture to be found in the soils of the protected coves and slopes than in those of the gentle and more regular slopes of uniform exposure. Spruce attains its maximum development in the mixed hardwood type, as do also most of the hardwoods.

SPRUCE SLOPES.

The slope type occupies the steeper slopes, with thin, stony soil, above the hardwood land, and may extend to the limits of tree growth, although not infrequently it gives way to a scrubby alpine growth composed almost exclusively of balsam. The type is characterized by a nearly pure coniferous growth with spruce predominating. Balsam is also present in appreciable quantities. The characteristic hardwood is yellow birch, which is generally of excellent quality. Hemlock, white pine, and a variety of hardwoods occur sparingly in the lower portions of this type or on the better soils of the lower ridges. Spruce of good quality, with tall, clean boles, closely set together in a dense stand, is produced on this type. As compared with the hardwood lands, spruce development is inferior here on account of the greater liability to windfall and poorer soils. Also because of the liability to windfall the forest is often comparatively young.

SECOND-GROWTH STANDS OF SPRUCE.

Partial or complete destruction, such as is effected by lumbering, windfall, or fires, will alter more or less completely the original character of any of these types, depending on the severity of the cutting or the extent of the windfall or fire. The succeeding second growth will develop a strong tendency to produce a groupwise association of the species, which in case of extended destruction may effect a temporary replacement of the original growth by either of two general forms—pure, even-aged stands of spruce or balsam alone or in mixture with each other, hemlock, arborvitæ, and hardwoods, or a two-storied form comprising an over wood, usually of such hardwoods as aspen, grey birch, fire cherry, and the like, and an understory of spruce. The last named is the typical one following fire. Nevertheless, if left undisturbed, the characteristics of these stands will usually revert to those of the parent type.

OLD-FIELD SPRUCE.

Because of their economic possibilities, particularly as forecasting the results which may be expected from plantations, the old-field spruce stands merit special mention. As their name implies, they occupy abandoned lands formerly under cultivation or in pasture. They are essentially even-aged and composed chiefly of spruce. Hereafter the discussion of second growth will refer to this character of the stand unless otherwise specified.

SOIL AND MOISTURE REQUIREMENTS.

Spruce is found on all kinds of soil. It is not exacting in its demands as to chemical composition, but prefers the well-drained gravelly and sandy loam soils of the mountain slopes and benches because of their favorable moisture conditions. Heavy soils are unfavorable to spruce because they hinder root penetration, accentuating its shallow rootedness, and thus render it more than ever liable to windthrow.

Moisture is the most potent factor influencing the local distribution of spruce on the various soils. Soils like sand or coarse gravel, which are devoid of binding material, quickly lose their surface moisture. They therefore afford scant opportunity for the development of spruce, even though the water table is but a few feet below the surface, since the water can not be reached by the superficial root system. Spruce can endure a wet soil, such as the clays and fine alluviums occurring in swamps. It reaches its best development, however, on the intermediate gravelly or sandy loam soils with free drainage, yet with a plentiful supply of surface or subsurface moisture.

Aside from these preferences of spruce, its distribution is dependent largely upon its ability to grow on sites unfavorable to its competitors. Spruce is not infrequently found almost solely in possession of large

areas on steep, rocky mountain slopes or wet bottom lands. Competition with the hardwoods is reduced both by their inability to adapt their root systems to the shallow soil and by excessive moisture conditions. Thus spruce is found most abundantly, not where the best conditions for its own growth exist, but where its competitors are not readily able to grow.

On the more favorable soils such agencies as fire, windfall, and fungous or insect attacks may prove a means by which the extension of spruce is made possible, provided a sufficient number of spruce seed trees remain to seed up quickly the ground formerly occupied by its competitors.

LIGHT REQUIREMENTS.

Spruce is one of the most tolerant of shade of our forest trees. Of the associates, only hemlock, and possibly sugar maple and beech, are more tolerant.[1] Spruce also possesses to a remarkable degree the power to recover and grow in a thrifty and normal manner following its release from long periods of suppression. Having once gained a foothold in the selection forest, the young spruce grips life tenaciously, struggles along for many years under the shade of the forest, and gradually forces its way upward as natural thinning reduces the number of its overtopping competitors. It is in fact to these qualities more than any others that spruce owes its ability to persist as a factor in the mixed selection forest of the Adirondacks, in the Northeast, and throughout its range.

Strangely enough these tolerant and recuperative qualities are most characteristically displayed by spruce in the selection forest. In the dense, even-aged pure stands, root competition and mechanical interference due to overcrowding enter in to complicate the situation. Trees which are suppressed under these conditions recuperate very slowly, if at all. Most often, when the stand is opened up sufficiently to afford the requisite amount of light and growing space, the suppressed crown is so reduced in size and vitality as to make recuperation imperceptible for a period of years. Such suppressed trees when released from overcrowding often succumb to windthrow or sun-scald.

Balsam although moderately tolerant is less so than spruce, the keen rivalry between the two species being due to other qualities in which balsam surpasses spruce.

WINDFIRMNESS.

Unlike most hardwoods and some of the conifers, notably the yellow pine and Douglas fir of the West, spruce develops a very superficial root system. On account of the intimate relation between the root and the crown of a tree and the active competition of root sys-

[1] Under the keenly competitive conditions which prevail in even-aged second-growth stands, spruce is able readily to suppress and kill out even these species.

tems, particularly those of the shallow-rooted species, spruce is much less windfirm when growing in crowded or pure stands than when growing in the open or in mixture with hardwoods. Thus the relative size and the form of the crown of spruce growing under different conditions of density and association is an index of its comparative windfirmness.

REPRODUCTION.

SOIL, MOISTURE, AND LIGHT.

Spruce finds its most favorable conditions for germination and subsequent early growth on the moist forest floor under cover of the not too dense stand of the selection forest. Here a suitable seedbed of moss, dead wood, and needle litter is found, which, being protected from exposure to the drying influences of sun and wind, affords sufficient moisture for germination and early development. That spruce appears to be selective in its seedbed requirements, and that observers are in disagreement as to whether it does better on mineral soil or on moss, dead wood, or duff, is largely because so much depends upon the moisture conditions in the different materials.

A plentiful supply of soil moisture is absolutely essential, not alone at the time of germination but throughout the period when the young plant is becoming established. This condition can be most readily obtained, and with the minimum amount of free moisture in the form of precipitation and seepage, under cover of the forest. That spruce will germinate and continue to grow and thrive on mineral soil can not be gainsaid, but only when such soil is protected from drying influences and is plentifully supplied with a constant amount of available moisture at or very near the surface. The same applies to to needle litter and old logs.

Needle litter when under a pure stand of spruce, particularly dense, unthinned, even-aged stands, is apt to accumulate much more rapidly than it will disintegrate. The upper layer forms a loosely compact mantle, which rapidly loses its surface moisture when exposed to drying influences. In the early spring or late fall, when humid conditions prevail, this mantle of needle litter contains sufficient moisture to induce germination, but the young plants are soon after destroyed by frost or drought. Furthermore, it is difficult for the young seedlings to extend their root systems through the litter to mineral soil. In consequence, it is not suitable for a seedbed, and in fact, under such circumstances, is a great detriment to reproduction. If no great depth of such litter exists, so that the disintegrating humus layer is practically at the surface, the seedbed is admirable, since the humus is very retentive of moisture, and the vegetable mold full of nourishment. Acid humus, however, is not suitable, for though it is most common in supermoist situations it is physiologically dry. The same general considerations that apply to needle litter apply to a still greater extent to the leaf litter from hardwoods, since, particularly

FIG. 1.—UMBRELLA FORM DEVELOPED UNDER VIRGIN FOREST CONDITIONS, SHOWING RECOVERY FROM SUPPRESSION.

FIG. 2.—A WIDESPREADING AND SUPERFICIAL ROOT SYSTEM; TREE OVERTURNED AFTER FIRE HAD BURNED OUT THE THIN SOIL OVERLYING THE ROCK.

CHARACTERISTICS OF GROWTH.

FIG. 1.—IN THE VIRGIN FOREST.

FIG. 2.—IN AN OPENING MADE BY A CUTTING 12 YEARS PREVIOUS.

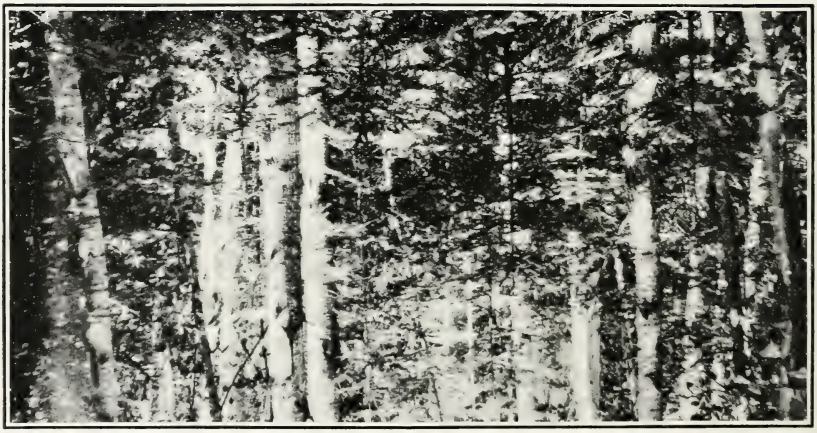

FIG. 3.—UNDER A STAND OF WHITE BIRCH AND POPPLE ON A BURN OF 40 YEARS AGO.

SPRUCE REPRODUCTION.

in the case of the thicker leaved hardwoods like maple, the duff not only sheds water and thus dries out quickly at the surface, but it also offers a considerable resistance to the root penetration of the germinating spruce seedlings.

The presence of moss is simply an indication of the presence of surface moisture throughout the growing season in sufficient amount to afford favorable conditions for spruce germination. An unbroken grass sod hinders the reproduction of spruce, both because it resists the progress toward the mineral soil of the rootlets of the young plant and because it makes excessive demands on subsurface moisture. In very moist and wet situations grass sod is seldom continuous, and in such places spruce has no trouble in starting under the cover and protection of the rank growth.

Protection from direct insolation and wind is also of importance, since they not only cause the drying out of the upper layers of the soil but induce rapid transpiration from the leaves of the young plants. This latter is particularly disastrous in the winter season when the soil is frozen and the seedlings are prevented from replenishing from the soil the supply of moisture thus given off. Such a condition is most likely to develop during a season of little snow, or where through exposure to an unbroken sweep of wind the snow has little chance to accumulate. In these open, bare situations, also, a warm day causing rapid thawing may be followed by freezing at night, which loosens the soil around the roots of the seedling and thus allows these tender members to be exposed to drought and frost.

In addition to moisture, a certain amount of light is absolutely necessary if the seedling is to endure beyond the period of germination. Since, however, spruce does not make extravagant demands in its light requirements, little difficulty is encountered in securing suitable conditions in this respect.

SEED PRODUCTION.

Authorities vary widely in their estimates of the frequency and abundance of spruce seed production. So far as is known, no observations have been carried on over a sufficient period of years to determine this with any degree of certainty. Spruce unquestionably produces a certain amount of seed annually, and conditions may be such that a good crop will occur for two successive years. In general, however, the interval between succeeding full seed crops varies from three to seven or eight years.

Spruce produces from 50 to 90 per cent perfect seed; from 60 to 80 per cent of which germinate. The seeds retain their vitality for at least two years under ordinary conditions of storage, and probably much longer. Variations are due to the conditions in the seed year. An off year not only produces fewer seeds, but the quality is poorer.

The age at which spruce begins to bear seed of good quality varies widely, depending on the soil quality, the exposure, and whether the tree is growing in the open or in the forest. In the virgin forest the production of seed is only indirectly a function of age and is more directly dependent upon size. The individual tree varies greatly as to the age when it becomes freed from suppression and enters upon a normal stage of development, thus gaining for itself a place in the full light of the upper crown classes. It appears from a study of the spruce made by the Bureau of Forestry[1] in cooperation with the Forest Commission of Maine in 1901, that in no case was a tree smaller than 5 inches in diameter at breastheight found bearing cones. The average age of spruce of this size in the virgin selection forest may be placed at about 100 years and in even-aged second-growth stands at from 20 to 30 years. Other observers have reported forest grown trees of three or four inches in diameter bearing seeds wherever their crowns were not directly under the shade of some other tree. The largest quantity and best quality of seed is produced in the virgin forest by trees from 10 to 18 inches in diameter at breastheight. In other words, spruce in the forest begins to bear seed when the crown succeeds in reaching the light, and begins to bear heavily when the top of the crown thickens. At first a few cones are borne near the main stem below the last year's growth, and as the crown thickens and spreads the cones are borne on the side branches. The first seed produced is of very poor quality.

In the open and under favorable soil and exposure conditions, seed production begins as early as the fifteenth or twentieth year, and heavy crops follow by the thirtieth or the thirty-fifth year. In the dense, even aged second-growth spruce stands the cones begin to be sparingly formed about the thirtieth year under the most favorable conditions; but a safe average for initial seed production in such stands would be not earlier than from the thirty-fifth to the fortieth year, with a full crop production about five or ten years later. Spruce continues to bear seed to an advanced age.

Spruce seeds begin to mature between September 15 and October 1, depending upon climatic conditions. Seed collecting, therefore, can be most profitably confined between these dates; or if a larger amount of seed is required than can be collected during this period, the work should be begun earlier and timed so as to reach completion by October. Upon full maturity the cones open and many of the seeds fall out, although not all, for frequently a considerable amount of seed can be seen on the surface of the late snows in February and March. After the cones are fully matured they are easily dislodged during lumbering; but if they are not disturbed, they remain on the trees until the next spring or early summer. The seed is light and winged

[1] Now the Forest Service.

and thus can be carried a long distance by the wind, variously estimated at from one-fourth to one-half mile. Its effective range under ordinary conditions is, however, very much less than that, probably not more than 200 feet.

COMPETITIVE DISADVANTAGES.

Spruce is subject to considerable competition with other species for the possession of the ground. In the mixed softwood and hardwood stands, beech and maple are its chief competitors; and in the softwood stands, balsam. Such species as witch hobble, briars, and the like often take possession of the ground after logging or fire, also fire cherry, aspen, and birch. These latter, however, soon open up their crown cover sufficiently to admit of spruce coming in beneath. The competition where briars and their associates occupy the ground after extensive cuttings or fire, is largely a matter of unfavorable seedbed conditions.

The competition of balsam, on account of its close association with spruce, is of vital importance. It almost invariably happens that on the replacement of stands where these two species occur in mixture, balsam largely predominates in the second growth. Balsam possesses the two distinct advantages over spruce of a plentiful supply of seed annually and of a decidedly more rapid growth, particularly in the seedling stage. While the moisture, seed bed, and to a great extent the light requirements are about the same for both, the more rapid growth of balsam enables it to extend its root system more vigorously and thus become established more quickly and more firmly under seed-bed conditions in which spruce, although germinating with equal facility, is later exterminated through subsequent drying out of the upper layers before its roots have become firmly established. Soil acidity under spruce growth is supposed to be inimical to the development of the spruce seedling, while the balsam seedling is unaffected by it. Spruce, however, will come in under balsam without difficulty. This has led to the supposition that a balsam growth must intervene between successive growths of spruce in order to "sweeten" the soil.

While the theory may be true, a contributory cause at least may be found in the character of the litter under the two stands. Spruce needle litter, particularly under dense forest conditions, is very resistant to decay. It thus has a tendency to accumulate faster than it can be decomposed, forming an inert soil cover of considerable depth, resistant to root penetration and porous, quickly draining away the water close to the surface so much needed by the small, slow-growing root system of the young spruce seedlings. This handicap the more vigorously growing balsam seedling is able to overcome so as to establish itself in place of the spruce. But balsam needle litter, decaying much more readily than the spruce, does not accumu-

late undecomposed to anything like the extent that spruce litter does. Thus the moist humus layers lie close to the surface and materially aid the young spruce to get established.

Further than these, however, a condition was recently observed which, if noted by other observers, has not been mentioned before in any published work on the spruce and which places the spruce at a still further disadvantage in its competition with balsam and with hardwoods as well. During the examination of the forest floor under the normal cover of even-aged spruce stands in the latter half of September (1910), a large quantity of germinated spruce seed was found which must have been from the recently ripened seed crop, since only the seed leaves were developed, and in many cases even the seed-coat still enveloped the tips of the embryonic leaves. These spruce germinates were so thick in places as to make it impossible to place a finger on the ground without crushing several. Balsam seedlings were also found, but remotely scattered as single individuals and almost without exception spring germinates, with well-developed stems and permanent leaves. One and two year old balsam seedlings were also present. Spruce of this age was entirely lacking, and seedlings of the previous spring's germination were also only sparingly represented.

Balsam seed trees were not very numerous, so that this condition did not of itself indicate much with relation to the behavior of that species; but subsequently a stand of almost pure balsam, within a short distance of the spruce plot just mentioned, was examined. Here, although the site was not quite the same, the density of the cover was very similar and in places conditions were even more favorable to germination and early growth than in the spruce stand. A close examination of the humus and light moss cover failed to disclose more than a scattering of balsam fall germinates, although the presence of new sound seeds in considerable quantity was disclosed. Balsam seedlings from spring germinates were plentiful, occurring as individuals, while 1 and 2 year old seedlings were also numerous.

In contrast to this condition spruce in the young growth of open pastures was observed to be much more prevalent than balsam. In explanation of this apparent reversal of the reproduction capacities of the two species, it seems entirely probable that in the fall soil moisture and general climatic conditions are, in the open, much less favorable to germination of spruce than in the forest. Furthermore, the principal seed distribution of spruce in the open, except in the immediate vicinity of seed trees, doubtless occurs later in the season from seeds subsequently dislodged from the cones by the winter storms. Thus in the open a relatively larger percentage of spruce seeds would lie over for spring germination with a correspondingly better chance of becoming permanently established.

As to the less favorable showing of balsam, this was unquestionably due in part to the smaller production of balsam seed, since there were fewer balsam than spruce seed trees in the particular locality where conditions were observed. Then, too, balsam seeds are heavier than those of spruce, so that they would not be carried so far by the wind, and balsam seedlings are also browsed by cattle much more than spruce.

If this behavior of spruce and of balsam in regard to time of seed dispersal and germination is typical of the two species, it can be readily seen that even with a less production of fertile seed than spruce, balsam would have a considerable advantage. The fall germination of spruce would subject the very young seedlings to a material reduction in numbers and vitality during the first winter as a result of winter-killing, while the loss to balsam from this cause would be comparatively insignificant.

Spruce is at a disadvantage, too, in its early struggle for a foothold in mixed hardwood stands. The usual explanation for its failure to come in more plentifully under a mixed hardwood forest after cutting is that the abundance of hardwood leaf litter on the ground at the time of seed fall prevents the spruce seeds germinating thereon from getting their roots into mineral soil, both because of the tough and impenetrable texture of the birch, maple, and other hardwood leaves and because the loosely compact surface layer of leaves sheds the moisture and quickly dries out before the young spruce can get established. While these undoubtedly are among the contributory causes, observations made in Waterville, N. H., in the spring of 1911 in connection with spruce reproduction plots under hardwoods suggest that here again the early seed dispersal habit of spruce works to the disadvantage of its reproduction. On several of these plots after the leaf litter of the previous fall was removed a considerable number of spruce germinates of that spring were counted. Many, however, were either wilted or had already succumbed to "damping-off," while others were bleached almost white and the stem and leaves were turgid and succulent, but without vigor, doubtless from too humid growing conditions and lack of sufficient light. This was particularly noticeable under moosewood and young hardwood brush with large coarse foliage. The absence of any one-year or two-year spruce on these plots was also noticeable. A marked contrast to this condition was found where any part of these plots happened to be protected from the heavy hardwood leaf fall by a group of suppressed spruce or small balsams or a pile of slash. Here there would be a generous number of spruce germinates and one and two year seedlings as well. In fact, reproduction appeared to be entirely satisfactory.

Whether fall germination takes place in these circumstances or not, the seeds, or germinates, will be covered with a thick layer of

hardwood leaves. In the spring the warm rains and sun start fermentation of this mulch, and while this at first affords conditions exceedingly favorable to the germination of the spruce seed, the young seedlings are unable to survive the continued heat and humidity and the general smothering effect of the hardwood leaf litter. The trouble thus seems to be not that the seedlings are unable to get their roots into mineral soil or other suitable material as is usually claimed, but that the heavy mulch prevents them from getting their shoots up into the needed light and air.

FORM.

The form of spruce varies widely and is determined largely by its stage of development and whether it grows in the open or in the forest. Like all other conifers, however, it always develops a well-defined central axis. In the open and before arriving at the stage in the forest where its lower limbs begin to be suppressed, spruce has a long, wide-spreading, conical-shaped crown, which extends well down to the ground. Its bole tapers rapidly. This form is retained to a large extent throughout life by the trees growing in the open, although their crowns open out and become less regular in outline with advancing age. In the forest the crown is more compact and has a conically topped head. As the tree grows in height the crown becomes shorter in proportion to the total height through the lower branches dying out more rapidly than new ones can be produced above. The bole at the same time takes on a more cylindrical form below the crown. Trees growing in the selection forest are likely to taper a little more rapidly than those in the even-aged stands, since they receive more side light and thus retain a longer crown than the more densely crowded, even-aged ones.[1]

LENGTH OF LIFE AND MAXIMUM SIZE.

Spruce may be classed as one of the longest-lived trees in the eastern United States, ranking with the white oak in this respect. In a virgin stand spruce seldom matures under 200 years, and the average age of the trees in such stands is undoubtedly nearer 250 or 300 years. According to Mr. Austin Cary, the oldest spruce which came under his notice in Maine was approximately 400 years (372

[1] An example of the variable form and development of spruce growing under different conditions is shown in the following abstract from a memoir on the Adirondack spruce by the late Col. W. F. Fox, Superintendent of State Forests, in the Report of the Forest Commission, State of New York, 1894: "A spruce 20 inches in diameter growing in a clump of spruces will yield five logs 13 feet 4 inches in length, while one of the same diameter in a scattered growth mixed with hardwoods will yield but four logs. In the one growing among hard woods after four logs have been cut from the trunk the diameter of the last or top log at its small end will be from 10 to 12 inches, but the limbs above this point will be so thick and large that the fifth log would not be over 5 or 6 inches at the top and would not be accepted by the lumberman. A tree of the same species and size growing in a clump will yield five logs because the shaft does not diminish in size so fast owing to the lighter growth of limbs that form its top. While the larger spruce are found scattered among the hardwoods, the tallest ones of like diameter are found growing in the spruce clumps."

years on the stump). The tree measured 28 inches in diameter and 97 feet in height, and a merchantable log 65 feet in length was cut from it. The central stem measured 200 cubic feet (from 1,200 to 1,500 board feet). When cut it was in thrifty growing condition with a long, full crown. The trunk was sound throughout except for a slight discoloration and softness in the sapwood near the top. The late Chas. H. Green, of White River Junction, Vt., gave the following details of a tree cut in Pittsfield, Vt., at an elevation of about 800 feet above the White River. The tree was cut into four 14-foot logs and a top log of 24 feet. The top diameter of the fifth log was 22 inches and the top diameter of the butt log 36 inches. The total scale was 3,590 feet. The tree was upward of 320 years old on the stump and was broken off at a height of 120 feet, where it had a diameter of 5 inches. A companion tree of 30 inches on the stump made six 14-foot logs, the last of which was 12 inches at the top end. He stated that when the logs reached the bank it was decided to blast them open in order to run them in a small stream and that when they reached the Connecticut River the rivermen used them as boats while poling logs out of the eddies.

SUSCEPTIBILITY TO INJURY.

FIRE.

Spruce is particularly suceptible to injury by fire on account of its slow growth in early life, the resinous character of its exudations, and its shallow root system. Ground fires are a menace to young spruce for a much longer period than to many of its associates. Its slow growth delays the formation of a protective corky layer of bark; and the long persistence of its lower branches lays it open to complete destruction by fires which its less tolerent neighbors would escape by having their crowns sufficiently elevated to be out of reach of serious damage.

On many of the situations where spruce grows the soil is very shallow. It is here dependent in large measure upon the humus and moss cover for the protection of its superficial root system. A surface or ground fire in such a place would almost certainly destroy this protective layer, even though it was not of sufficient intensity to scorch the trunks of the trees. Serious damage to the roots would almost inevitably result, thus causing the death of the stand outright or creating a condition favorable to windthrow.

On account of the tolerance and consequently the relatively heavy crown of spruce, a large quantity of inflammable débris is left on the ground after lumbering, which makes the fire menace much greater in spruce stands than in those of the pine and other species in the region of its occurrence. This menace persists for several years, probably not less than from 7 to 10 years, even when the tops are lopped. Lopped tops in contact with the ground will have commenced to

decay by that time. There are so many twigs or lops, however, that they must be piled out of the way of logging, and thus elevated from the ground they remain in an anflammable condition for a long time. Windrows of spruce lops even under fairly moist conditions will support the weight of a man, thus showing them to be in comparatively sound condition, at least from 7 to 10 years after cutting. Even if they could be scattered over the ground, their bowed form and elasticity would render it difficult to secure an intimate contact with the ground unless they were cut up into small pieces. Their rapid decay is still further hindered by the resinous character of the wood.

FROST.

Spruce is rather generally subject to splitting, particularly in very cold exposed situations. This defect is caused by an unequal shrinkage between the heart and sapwood under the action of a sudden drop in temperature below freezing. It may also be accentuated to some extent by the swaying of the tree in the wind when in a frozen condition. Spruce having this defect is known among lumbermen as "seamy" spruce. If the grain of the wood is straight, the defect will not cause much loss in sawing; but if it is not straight, the tree is useless except for pulp. As frost crack results from climatic conditions, its prevention is not feasible. Spruce is not particularly susceptible to the defect known as "cup or ring shake."

SUN.

Trees grown in a dense forest usually have their boles well cleared of branches. Therefore when a portion of the stand is removed injury may result from sun scald through exposure of the remaining trees to direct insolation. The damage is generally confined to the side of the tree facing the southeast, and conditions are most favorable to its occurrence in the late winter and early spring. It may result from the cambium on that side of the tree becoming prematurely active under the influence of a period of mild weather and a heavy freeze coming on afterwards and killing the new growth. A thawing of one part of the tree under the influence of direct insolation while the rest remains frozen might also cause it. Separation of bark and wood and the collection of moisture in the cavity almost inevitably follow such thawing and afford suitable opportunite for the entrance and development of fungous spores. Such a condition gives rise to a defect known as "spruce canker."

INUNDATION AND ICE GIRDLING.

Although spruce will grow and thrive in moist situations, it is permanently injured if not killed outright by inundation, depending upon the duration of the flooding. Spruce is also killed by girdling [1] when the inundation is accompanied by the formation of ice about the tree trunks.

[1] See p. 57, Bulletin 26, U. S. Department of Agriculture, Division of Forestry, Oct. 1899.

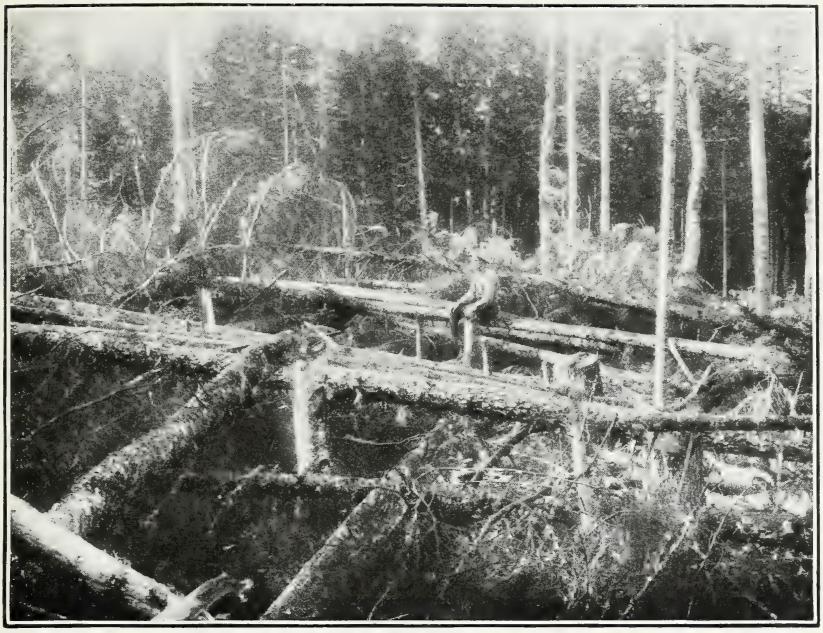

FIG. 1.—WINDFALL AFTER LOGGING.

FIG. 2.—STAND KILLED BY FIRE WHICH DESTROYED THE THIN SOIL COVER OF MOSS, EXPOSING THE ROOTS WHICH REST ON THE UNDERLYING ROCK STRATA.

DAMAGE TO SPRUCE.

ANIMALS.

Young spruce may be severely damaged by the tearing off of its bark by deer when rubbing their antlers to remove the "velvet." Balsam, however, is much more liable to injury of this sort than is spruce, presumably because of its smoother bark and the healing effect of its resin. Hedgehogs also damage spruce to some extent by gnawing the bark. Squirrels and mice eat enormous quantities of seed, and undoubtedly do further damage by burrowing about the roots, thus exposing them to danger of fungous infection. The rodents may even be the means themselves of inoculation. Squirrels, particularly, feed on the fruiting bodies of different fungi, which can often be found on dead limbs along the trunk of spruce where they have been carried and partly eaten.

GRAZING.

Spruce is susceptible to very little injury by the browsing either of deer or domestic animals. When very young the seedlings are liable to serious injury by being trampled by the grazing stock. If it were not for this, the presence of stock in young spruce stands would be of advantage in keeping the grass cropped down and the young hardwoods and balsam browsed.

There is at the present time a tendency in parts of the spruce regions of New Hampshire and Vermont to allow pasture land to grow up to spruce, at the same time allowing stock to graze as long as they can find sufficient pasturage. Such an attempted dual use of the land is of advantage to neither the cattle grazed nor to the forests to be grown. The resulting stand of spruce is very ragged and uneven-aged, being composed of large, spreading-crowned, scrubby trees interspersed by occasional thickets of younger growth. These latter come up in the openings which are from time to time cut off from grazing by the interlacing of the low crowns of the larger trees, which hinders the passage of the stock. On account of the gradual encroachment on the intervening areas of the crowns of the larger trees, many of these younger saplings are eventually suppressed.

The yield from such a stand is very much less than the land is capable of producing; the quality of the material in inferior, and much of it is useless even for pulp. Much time also is wasted in cutting the big-limbed, scrawny trees, which materially reduce the output per day, increase the cost, and yield heavy sticks difficult to handle. Thus the normal value of the land is reduced not only as a pasturage investment but as an investment for pulpwood production.

WIND AND SNOW.

The susceptibility of spruce to damage by windthrow is very great on certain situations on account of the shallow nature of its root system. The foliage and young shoots may be considerably damaged by hail and are thus rendered more vulnerable to insect

and fungous attacks. Wet snow and sleet are also responsible for considerable damage to young spruce. The weight of snow will often bend the young trees over beyond the point where they can recover their erect position.

FUNGOUS GROWTH.[1]

Spruce is susceptible to injury by fungous growths of many sorts, which gain entrance into the wood through wounds resulting from a variety of causes. Some of the fungi can not thrive on a thrifty growing tree, but are secondary causes of death. Others, however, are unselective as to the thrift of their host.

Three root parasites[2] which attack the spruce are *Polyporus schweinitzii*, *Poria* (*Polyporus*) *subacida*, and *Fomes* (*Polyporus*) *annosus*. *Polyporus schweinitzii*, the worst of these, is very prevalent throughout the northern spruce and fir forests, where it attacks old and young trees alike, as does also *Poria subacida*. To what extent *Poria subacida* is the cause of the death of the tree, however, is not known, nor whether it attacks perfectly healthy trees; but it is known to be particularly destructive to dead timber. *Fomes annosus*, although very destructive in the forests of Europe, has not been accounted so in our eastern forests up to the present. These fungi usually spread through the soil and gain entrance to the tree through the roots, which makes them difficult to detect and still more difficult to combat. While it will not do to hunt out diseased trees as is done in Europe, it may prove of advantage whenever an infected group of trees is found in lumbering to cut all nearby trees. Decay will not, in many cases, have extended so far up the trunk as to prevent one or two merchantable logs being obtained.

Three wound parasites[2] which do a great deal of damage to spruce are *Trametes pini abietis*, *Fomes* (*Polyporus*) *pinicola*, and *Polyporus sulphureus*. They gain entrance to the tree above ground through wounds on the trunk and branches, and spread up and down the trunk from the point of infection to the topmost branches and to the roots. *Trametes pini abietis* very commonly attacks both the heartwood and sapwood of spruce and literally riddles them with small holes. *Fomes pinicola*, while it attacks living trees, is generally found on those individuals which have a weakened vitality, and is one of the first to settle on such trees as have met death through other causes. *Polyporus sulphureus* is found on spruce, but is more prevalent on hardwoods. There are undoubtedly many others of

[1] Those desiring detailed information concerning fungous diseases and how to combat them should communicate with the Division of Forest Pathology, Bureau of Plant Industry, Washington, D. C.

[2] Von Schrenck, Hermon: "Some Diseases of New England Conifers," U. S. Department of Agriculture, Div. of Veg. Phys. and Path., Bulletin 25, 1900.

this type of fungous growth which prey upon the spruce, but those enumerated are the most common and most destructive.

It is obviously impossible to introduce intensive protective measures in our wild and uncultivated forests. However, it is possible, and in the long run it will be profitable, to adopt such measures as will certainly aid in prolonging their health and usefulness. In the process of lumbering, particularly where the selection system is being employed, a careful scrutiny should be made of all trees which are to be left. Merchantable trees in a defective condition, whatever their size, should be removed in order to get the present value of their sound portions and at the same time prevent so far as possible their becoming a menace to the healthy trees remaining. This would include the cutting of standing dead and down timber when marketable. In similar manner, areas upon which the timber has been killed by fire, windfall, or serious insect attacks, should be lumbered immediately upon the discovery of the damage. If such timber is cut immediately, its value will be only slightly, if at all impaired, and it will yield as good lumber as before its death. This logging will, in certain instances, entail a somewhat greater expense. The disposal of slash by burning after lumbering, using suitable safeguards, is another precaution which will be found desirable. If slash is allowed to remain on the ground, it constitutes a center of infection for fungous diseases and insect pests, thus jeopardizing the health of the remaining timber.

INSECTS.[1]

Spruce has many insect enemies which prey upon its bark, wood, twigs, and foliage. Those known as bark and wood miners cause the greatest damage. They attack the old and valuable timber and are either primary or secondary causes of its death. Young trees are subject to injury by the white-pine weevil (*Pissodes strobi* Peck) and the spruce gall louse (*Chermes* sp.). The latter affects the young twigs and the former the terminal shoots. As a result of their work the trees become deformed or stunted in growth.

Among the bark miners the southern pine beetle (*Dendroctonus frontalis* Zimm.) and the eastern spruce beetle (*Dendroctonus piceaperda* Hopk.) are considered the most serious pests. To the former has been attributed the destruction of a vast amount of spruce timber in West Virginia and the adjacent region, while the eastern spruce beetle is accounted responsible for the ravages of past years in Maine and New Hampshire. The attacks of the southern pine beetle are disastrous to both pine and spruce in areas south of Penn-

[1]Those desiring detailed information concerning forest insect pests and methods of combating them should communicate with the Division of Forest Insect Investigations, Bureau of Entomology, Washington, D. C.

sylvania; but thus far the eastern spruce beetle is credited with confining its baleful activity to the spruce alone and to areas north of West Virginia. Both of these insects attack perfectly sound, thrifty timber of the best quality—that is, trees from 10 to 12 inches in diameter and larger. Although they manifest a preference for standing trees, they will breed in windfallen trees and, more rarely, in stumps and logs.

Certain insects which infest the spruce are able to do their work only when the vitality of the tree has been reduced either by a former insect attack or through disease. The wood miners work within the woody parts of the tree rather than in the cambium, and continue their work after its death, as well as in the log after it is cut. They are usually of no detriment to the health of the living tree, but their excavations into both the heartwood and sapwood cause wormhole defects and afford favorable means for the entrance of fungi.

While the insect enemies of spruce have many natural enemies, such as the birds, parasitic insects, and fungi, and predacious insects which feed on and destroy their young, their ravages are not always held in check by such means. According to Dr. A. D. Hopkins,[1] forest entomologist of the U. S. Bureau of Entomology, the general methods to be adopted are as follows:

For the southern pine beetle: (1) remove and burn the infested bark from the trunks of the trees while still standing; (2) place the infested portions of the trunks in water; or convert the infested trees into cordwood, lumber, or other products and burn the slabs or bark before the beetles leave the bark.

For the eastern spruce beetle: (1) Regulate the winter cutting so as to include as many of the infested, dying, and dead trees as possible, and place the logs from them in water before the first of June; (2) regulate the summer cutting so that as many recently attacked trees as possible may be cut and the bark removed from the trunks and stumps; (3) girdle, early in June, a large number of trees, in the vicinity of infested localities where logging operations are to be carried on the following summer and winter, the girdled trees to be felled and the logs containing the broods of the insect attracted to them either peeled or placed in water before the first of the succeeding June. The trees selected to be girdled should be sound and healthy and not less than 15 inches in diameter, and the girdling should be done by hacking the tree with an ax through the bark into the sapwood and around the trunk 2 or 3 feet above the base.

A large percentage of dead spruce remains sound for a considerable period after being killed by these insects, and should be salvaged when

[1] U. S. Department of Agriculture, Div. Ent. Bulletin 28; also U. S. Department of Agriculture Farmers' Bulletin 476.

possible. Since the mature living timber is the most subject to attack, the cutting over of the remaining virgin tracts, using an approximate diameter limit of 14 inches at breast height, will greatly reduce the danger of subsequent serious damage arising from this source.

GROWTH.

Spruce varies more or less widely in growth, form, and development with the character of the stand, the density of the stocking, and the exposure and quality of the soil. Virgin or old-growth stands present a distinctly different set of conditions from the second-growth stands.

The virgin stands are, without exception, of the natural selection form, in which each tree or small group of trees develops individually; all ages and sizes are represented, from seedlings to overmature veterans, but the older age classes generally predominate. The second-growth stands, on the other hand, are in a large measure of even-aged form, either in groups or over whole areas; the trees all start at approximately the same time and develop as a unit rather than as distinct individuals. The conditions surrounding these two modes of development give rise to differences not only in the rate of growth in volume, height, and diameter, but in the form of bole of the individual tree.

HEIGHT GROWTH.

In the virgin forest or in one managed under the selection system, the height growth of spruce bears no definite relation to its age. It is the soil quality, or site quality, whose influence is particularly manifested in height growth. Mature spruce in the virgin-forest types in which it characteristically occurs shows the same relative height development in Maine and the Adirondacks for the corresponding soil types. The "spruce swamp" shows the least development in height, averaging for the tallest trees about 60 feet in Maine and 72 in the Adirondacks, followed by the "spruce flats" and "spruce slopes," on which the heights are nearly the same, namely, 70 feet in Maine and 75 feet in the Adirondacks. Spruce reaches its best development on the "spruce and hardwood lands," with heights of 75 feet for Maine and 80 feet for the Adirondacks. The differences in average height for similar types in Maine and the Adirondacks are in large measure accounted for by the fact that the averages for the Adirondacks include a large percentage of virgin growth, while those for Maine are based almost entirely on figures from cull forests, which are lacking in the larger sizes. The inferior height growth in the "spruce swamp" and "spruce slope" situations is attributed to the fact that not only the growth in these situations is slower, but also that the timber in many cases is second growth. Stands in these situations are particularly likely to be overturned by the wind on attaining a certain

height. The succeeding second growth may pass through the same stages, so that these stands may be relatively young.

Table 4 gives height growth of selection stands in Maine, New Hampshire, the Adirondacks, and West Virginia. It will be noted that the heights in New Hampshire are below those in Maine and New York, particularly in the larger diameters. This is undoubtedly due to the fact that the New Hampshire data were collected toward the southern edge of the White Mountain spruce forests, where the prevailing conditions are less favorable to spruce than those farther north. The values given for New York, on the other hand, are doubtless somewhat high because of the exclusive use of dominant trees as a basis for the height curve. The average height development is slightly better in New Hampshire than in Maine and is somewhat better in Maine than in New York for the same type or site.

TABLE 4.—*Height growth of spruce (based on diameter).*

[CURVED.]

Diameter breast high.	Maine.[1]		New Hampshire.[2]		New York.[3]		West Virginia.[4]	
	Height.	Basis.	Height.	Basis.	Height.	Basis.	Height.	Basis.
Inches.	*Feet.*	*Trees.*	*Feet.*	*Trees.*	*Feet.*	*Trees.*	*Feet.*	*Trees.*
1	12	.....	11	.....	11	.....	10	.....
2	18	.....	17	.....	17	.....	16	.....
3	24	.....	23	.....	23	.....	22	.....
4	29	5	29	.....	29	.....	28	.....
5	34	3	34	.....	34	1	34	1
6	38	6	38	21	39	6	40	3
7	42	8	43	36	43	8	46	1
8	46	13	46	76	47	24	51	5
9	50	17	50	75	50	19	56	12
10	53	31	53	87	53	55	61	26
11	56	21	56	76	56	37	66	34
12	59	23	58	87	58	29	71	42
13	62	19	61	54	60	18	75	36
14	65	24	63	68	62	23	79	46
15	67	13	65	33	64	15	82	22
16	70	13	67	36	66	5	86	39
17	72	13	63	24	68	4	89	20
18	74	19	69	21	70	2	92	29
19	76	5	71	13	71	1	95	16
20	78	7	72	9	73	.....	97	27
21	79	5	72	3	74	1	100	18
22	81	4	73	3	76	1	102	21
23	83	4	74	.....	.....	.....	104	13
24	84	1	74	.....	.....	.....	105	8
25	86	1	75	.....	.....	.....	107	9
26	87	.....	75	3	.....	.....	109	7
27	.....	.....	.....	.....	.....	.....	110	6
28	.....	.....	.....	.....	.....	.....	111	9
29	.....	.....	.....	.....	.....	.....	112	6
30	.....	.....	.....	.....	.....	.....	113	2
31	.....	.....	.....	.....	.....	.....	114	2
32	.....	.....	.....	.....	.....	.....	115	.....
33	.....	.....	.....	.....	.....	.....	116	1
34	.....	.....	.....	.....	.....	.....	117	1
	.....	260	.....	725	.....	250	.....	462

[1] Spruce slope type. Data collected by R. S. Hosmer.
[2] Spruce slope type. Data collected by T. S. Woolsey, jr.
[3] Spruce hardwood type (dominant trees only). From data collected by the Conservation Commission of New York.
[4] Spruce slope type. Data collected by John Foley.

In the even-aged, second-growth forests, the individual tree is not subjected to long or varied periods of suppression. All of the trees

which gain positions in the main crown cover start at about the same time and develop with very little interruption. Their height and age may consequently be easily correlated. The following table shows the average height of the dominant and intermediate trees comprising even-aged second-growth spruce stands of different ages and on sites of different quality, measured in Maine, New Hampshire, and Vermont in the fall of 1910.

TABLE 5.—*Height growth of spruce in even-aged, old pasture stands in Maine, New Hampshire, and Vermont according to age and site qualities.*

[Average height of all dominant (including codominant) and intermediate trees in stands of different ages.]

[CURVED.]

Age.	Site qualities.			Basis.
	I.	II.	III.	
Years.	*Feet.*	*Feet.*	*Feet.*	*Sample plots.*
20	24	19	14	.....
25	31	25	20	1
30	36	31	25	.....
35	42	36	30	1
40	46	40	34	.....
45	51	44	37	1
50	55	47	40	6
55	58	50	42	6
60	61	53	45	8
65	64	55	47	16
70	66	57	49	14
75	68	59	50	4
80	70	61	52	1
85	72	63	53	.....
90	73	64	55	.....
95	74	65	56	1
100	76	66	57	.....
				59

From sample plot data collected in 1910.

For purposes of comparison the growth in height of Norway spruce is given in Table 6.

TABLE 6.—*Height growth of Norway spruce.*[1]

Age.	Average height of stand.
Years.	*Feet.*
5	8
10	16
15	24
20	32
25	39
30	45
35	50
40	54
45	58
50	61
55	64
60	66

[1] Based on all measurements of all trees in 11 plantations (8 Quality I and 3 Quality II) 24–55 years old (curved), made by Messrs. Tillotson, Barrows, and Williamson, of the Forest Service, in 1911, in Rhode Island, Connecticut, Illinois, and Iowa.

There is little doubt that Norway spruce makes a better height growth in early life than our native spruce. It is well to remember, however, in making comparisons in this particular instance, that the two grow under entirely different sets of conditions. While the native spruce has developed from seed under the keenest possible competitive conditions, the Norway stock was in all likelihood nursery grown, so spaced when planted as to eliminate undesirable competition during early life, and possibly even cultivated. Then, too, such plantations in general have been made on a rather better soil even than that on which the average first quality red spruce stands are found.

A comparison of the height growth of spruce seedlings in the forest and in the open is shown in Table 7.

TABLE 7.—*Height growth of spruce seedlings.*

Age.	Height.	
	In the forest.[1]	In the open.[2]
Years.	*Feet.*	*Feet.*
5	0.3	0.8
10	0.7	2.4
15	1.1	6.0
20	1.5	10.0
25	2.0	16.0
30	2.6	28.0
35	3.3	35.0
40	4.1	.....
45	5.0	.....

[1] Based on 615 trees. Data collected by R. S. Hosmer, 1901, on the New York State Forest Reserve.
[2] From p. 50, "Forest Conditions of Northern New Hampshire," Bulletin 55, Bureau of Forestry, U. S. Dept. of Agriculture.

The column of height in the open is entirely conservative, as will be noted by comparing it with Table 5.

DIAMETER GROWTH.

The growth in diameter of spruce in virgin and other selection-form forests is, like the height, largely independent of age. The relation between diameter and age, however, can more readily be established than that between height and age, since merely from a stump analysis results closely approximating the truth can be obtained.

TABLE 8.—*Diameter and age of spruce in Maine.*[1]

[(*a*) Averaged according to age.]

Class.	Number of trees.	Per cent of total number.	Average age.	Average butt diameter.	Average length.	Average top diameter.
				Inches.	*Feet.*	*Inches.*
Under 125 years	52	4.9	114.5	11.5	26.4	8.0
125–150 years	120	11.4	138.7	12.1	28.5	8.5
150–175 years	210	20.0	162.6	12.9	29.9	8.6
175–200 years	218	20.8	182.6	13.5	30.3	8.9
200–225 years	210	20.0	210.8	15.0	31.3	9.9
225–250 years	125	11.9	235.5	15.9	32.2	10.0
250–275 years	72	6.9	260.3	16.0	32.9	10.3
275–300 years	29	2.8	285.6	17.5	34.4	11.5
Over 300	14	1.3	311.6	18.5	37.1	12.0
Average of all[2]	1,050	.....	192.0	14.1	30.6	9.2

[(*b*) Averaged according to butt diameter.]

Class.	Number of trees.	Per cent of total number.	Average age.
Under 10 inches	42	4.0	162.0
10–11 inches	97	9.2	170.1
11–12 inches	123	11.7	171.7
12–13 inches	158	15.1	174.0
13–14 inches	162	15.3	[3] 189.1
14–15 inches	117	11.2	[3] 185.4
15–16 inches	94	9.0	197.7
16–17 inches	76	7.3	214.0
17–18 inches	62	5.9	217.1
18–19 inches	43	4.1	228.7
19–20 inches	19	1.8	230.1
Over 20 inches	57	5.4	244.8
	1,050	.....	.....

[1] From a special report "On the Growth of Spruce, by Austin Cary, in the Second Annual Report of the Forest Commissioner of the State of Maine, 1894. In explanation of the foregoing table Mr. Cary says: "In all, 1,050 spruce logs were examined for this purpose, taken on drives and mill yards. The length and end diameters of each log were measured, and the rings of the butt counted to ascertain the age. About two-thirds of the logs were grown in the western part of the State on the drainage of the Androscoggin. The remainder were partly from the Kennebec, partly from the Aroostock branches of the Penobscot. A small proportion of the logs measured were cut for pulp, which renders the selection all the more representative. The tables which embody the results of the work need, it would seem, very little explanation. The trees were first divided into age classes, and the dimensions of the logs in each class averaged. Then the same logs were divided according to butt diameters and the average age ascertained for trees of each size. The most usable result of the work is the grand average of these facts for the whole 1,050 logs. The average dimensions of the logs represent a tree containing about 23 cubic feet, or say 120 board feet, and this was grown on the average in 192 years. Adding to the log 2 cubic feet for stump and 7 more for the top, adding also to the age 20 more years for the height growth of the stump, then dividing contents by age gives the figures fifteen-hundredths cubic feet. That is to say, a spruce tree on the average and throughout its life until cut, maintains a growth of 1 cubic foot in six and two-thirds years. In adult life the growth per tree would be considerably greater. In young seedlings it would for many years be less. The percentage of growth to stand can not be immediately derived from these figures."

[In connection with the information just quoted, it seems evident that the words "log" and "tree" are used synonymously in referring to the "used length."—Author.]

[2] A log of these average dimensions contains 23 cubic feet, or about 120 board feet.

[3] A 13½-inch tree, of course, is not as a rule older than a 14½-inch tree. The irregularity shown in the series would doubtless be corrected if the larger number of trees was taken.

Average of 50 pine logs: Age, 102.8; butt diameter, 16.1; length, 30.3; top diameter, 11. A log of these dimensions contains 30 cubic feet, or about 175 board feet.

It is in most cases of little practical value to the lumberman to know the direct relation between the actual age and the diameter of trees in a selection forest. A knowledge of the length of time required for a tree to grow from 1 inch diameter class to the next is, however, important. Tables 9, 10, and 11 show this as well as the corresponding rate of growth per annum of each diameter class.[1]

[1] Besides showing these values based on an average of all trees measured, the West Virginia and Adirondack tables show absolute maximum and average maximum values as well. These are obtained by using only values representing maximum and average minimum growth conditions, eliminating all periods which show the effect of suppression.

TABLE 9.—*Diameter growth of spruce in Maine, by types.*[1]

[Based on the last 20 years.] [CURVED.]

Diameter breast high.	Lower spruce and hardwood land, 564 trees.		Upper spruce and hardwood land, 379 trees.		Lower spruce slope, 144 trees.		Upper spruce slope, 87 trees.		Average of all types, 1,174 trees.	
	Periodic annual growth.	Time required to grow 1 inch.	Periodic annual growth.	Time required to grow 1 inch.	Periodic annual growth.	Time required to grow 1 inch.	Periodic annual growth.	Time required to grow 1 inch.	Periodic annual growth.	Time required to grow 1 inch.
Inches.	*Inches.*	*Years.*	*Inches.*	*Years.*	*Inches.*	*Years.*	*Inches.*	*Years.*	*Inches.*	*Years.*
5	0.036	28	0.054	19	0.015	67	0.026	38	0.034	29
6	.048	21	.063	16	.022	45	.030	33	.045	22
7	.063	16	.071	14	.032	31	.034	29	.056	18
8	.080	13	.078	13	.046	22	.038	26	.068	15
9	.098	10	.085	12	.067	15	.041	24	.081	12
10	.114	9	.091	11	.093	11	.044	23	.093	11
11	.126	8	.096	10	.113	9	.047	21	.105	10
12	.136	7	.102	10	.124	8	.049	20	.115	9
13	.142	7	.109	9	.127	8	.052	19	.122	8
14	.146	7	.112	9	.126	8	.055	18	.126	8
15	.148	7	.112	9	.122	8	.058	17	.129	8
16	.150	7	.109	9	.116	9	.060	17	.130	8
17	.148	7	.106	9	.110	9	.062	16	.129	8
18	.146	7	.106	9	.103	10	.062	16	.126	8
19	.142	7	.106	9	.096	10	.062	16	.122	8
20	.138	7	.106	9	.091	11	.060	17	.116	9
Average	.141	7	.104	10	.112	9	.052	19	.119	8

[1] From data secured by R. S. Hosmer, 1902, on partially culled land in Squaw Mountain Township, Me., and including trees of all crown classes.

TABLE 10.—*Diameter growth of spruce in New York.*[1]

[All types, spruce-hardwood type chiefly; dominant trees only.] [CURVED.]

Diameter breast high.	Absolute maximum.		Average maximum.		Average.		Basis.
	Periodic annual growth.	Time required to grow 1 inch.	Periodic annual growth.	Time required to grow 1 inch.	Periodic annual growth.	Time required to grow 1 inch.	
Inches.	*Inches.*	*Years.*	*Inches.*	*Years.*	*Inches.*	*Years.*	*Trees.*
[2] 1	0.176	5.7	0.111	9.0	0.046	21.7	.....
2	.218	4.6	.140	7.1	.061	16.4	.....
3	.253	4.0	.164	6.1	.075	13.3	.....
4	.282	3.5	.186	5.4	.089	11.2	.....
5	.309	3.2	.205	4.9	.101	9.9	10
6	.324	3.1	.217	4.6	.110	9.1	42
7	.331	3.0	.223	4.5	.115	8.7	32
8	.328	3.0	.223	4.5	.118	8.5	57
9	.317	3.2	.219	4.6	.121	8.3	46
10	.297	3.4	.210	4.8	.124	8.1	65
11	.270	3.7	.197	5.1	.124	8.1	44
12	.245	4.1	.184	5.4	.123	8.1	27
13	.216	4.6	.168	6.0	.119	8.4	19
14	.187	5.3	.150	6.7	.112	8.9	25
15	.156	6.4	.128	7.8	.101	9.9	15
16	.132	7.6	.110	9.1	.089	11.2	4
17	.110	9.1	.093	10.8	.076	13.2	4
18	.....	.....	.....	.....	.064	15.6	2
19	.....	.....	.....	.....	.051	19.6	1
20	.....	.....	.....	.....	.....	.....	.....
							393

[1] From data collected by the Conservation Commission of New York in 1912 on culled land in Essex and Herkimer Counties.

[2] The time required to grow to a diameter of 1 inch at breastheight was 11 years for "absolute maximum" growth conditions, 17 years for "average maximum," and 36 years for "average."

TABLE 11.—*Diameter growth of spruce (virgin) in West Virginia.*[1]

[Spruce slope type.] [CURVED.]

Diameter breast high.	Absolute maximum.		Average maximum.		Average.		Basis.
	Periodic annual growth.	Time required to grow 1 inch.	Periodic annual growth.	Time required to grow 1 inch.	Periodic annual growth.	Time required to grow 1 inch.	
Inches.	*Inches.*	*Years.*	*Inches.*	*Years.*	*Inches.*	*Years.*	*Trees.*
[2] 1	0.202	5.0	0.126	7.9	0.051	19.6	.....
2	.220	4.5	.138	7.2	.056	17.9	.....
3	.235	4.3	.148	6.8	.060	16.7	.....
4	.250	4.0	.157	6.4	.064	15.6	.....
5	.262	3.8	.166	6.0	.069	14.5	1
6	.274	3.6	.174	5.7	.074	13.5	3
7	.284	3.5	.182	5.5	.079	12.7	1
8	.291	3.4	.188	5.3	.084	11.9	5
9	.296	3.4	.193	5.2	.090	11.1	12
10	.300	3.3	.198	5.1	.096	10.4	24
11	.300	3.3	.201	5.0	.102	9.8	27
12	.300	3.3	.203	4.9	.106	9.4	37
13	.298	3.4	.204	4.9	.109	9.2	28
14	.294	3.4	.202	5.0	.110	9.1	42
15	.290	3.4	.200	5.0	.111	9.0	19
16	.282	3.5	.196	5.1	.110	9.1	33
17	.275	3.6	.192	5.2	.108	9.3	13
18	.265	3.8	.186	5.4	.106	9.4	17
19	.254	3.9	.178	5.6	.103	9.7	8
20	.243	4.1	.172	5.8	.100	10.0	20
							290

[1] From data collected by John Foley in 1903 in Greenbrier County and including trees in all crown classes.
[2] The time required to grow to a diameter of 1 inch at breastheight was 7 years for "absolute maximum" growth conditions, 11 years for "average maximum," and 26 years for "average."

Diameters in even-aged stands vary directly with the age of the stand, so that the relationship of one of the other is of considerable importance. This relationship is brought out in Table 12, which is based on the average diameter growth of the dominant (including codominant) and intermediate trees.

TABLE 12.—*Diameter growth of red spruce in even-aged, old pasture stands in Maine, New Hampshire, and Vermont, according to age and site qualities.*

[Average diameter breast high [1] of all dominant (including codominant) and intermediate trees in stands of different ages.]

Age.	Site qualities.			Basis.
	I.	II.	III.	
Years.	*Inches.*	*Inches.*	*Inches.*	*Sample plots.*
20	3.8	3.1	2.4	.....
25	4.9	4.0	3.2	1
30	5.9	4.9	3.9	.....
35	6.8	5.7	4.6	1
40	7.5	6.3	5.2	.....
45	8.1	6.9	5.7	1
50	8.6	7.4	6.1	6
55	9.0	7.7	6.4	6
60	9.3	8.0	6.7	8
65	9.5	8.2	7.0	16
70	9.7	8.5	7.2	14
75	9.9	8.7	7.4	4
80	10.1	8.9	7.6	1
85	10.2	9.0	7.8	.....
90	10.4	9.2	8.0	.....
95	10.6	9.4	8.2	1
100	10.8	9.5	8.4	.....
				59

[1] From sample plot data collected in 1910.

For purposes of comparison Table 13, giving diameter growth of Norway spruce (*Picea excelsa*) is included.

TABLE 13.—*Diameter growth of Norway spruce.*[1]

[CURVED.]

Age.	Average diameter breast high of stand.
Years.	*Inches.*
5	1.0
10	2.8
15	4.4
20	5.7
25	6.8
30	7.7
35	8.4
40	9.0
45	9.6
50	10.2
55	10.8
60	11.4

[1] Based on the measurement of all trees in 11 plantations (8 Qualities I and 3 Quality II) 24–55 years old, made by Messrs. Tillotson, Barrows, and Williamson in 1911, in Rhode Island, Connecticut, Illinois, and Iowa.

Even more than with height comparisons it is necessary to bear in mind the influence of soil, spacing, and cultural methods on the diameter growth of volunteer stands and plantations when drawing conclusions from the foregoing figures as to the relative growing qualities of red and Norway spruce.

SECTIONAL AREA GROWTH.

The growth in sectional area, or the increase in the superficial area of a given cross section, is effective as a means of comparison for even-aged stands of different ages or of the same age but of different site qualities. Either the total basal area of the stand at a definite height from the ground, usually at breastheight, or the basal area of the average tree, may be employed. Table 14, covering second-growth, even-aged spruce stands of the old pasture type shows the relative average total basal area of stands of different ages and site quality based (1) on all green trees; (2) on green trees 6 inches and over; (3) on all dominant trees; and (4) on all dominant and intermediate trees.

TABLE 14.—*Breast-high sectional area growth of red spruce in even-aged, old pasture stands in Maine, New Hampshire, and Vermont, according to age and site qualities.*

QUALITY I.

[CURVED.]

Age.	All green trees.			Green trees 6 inches and over.			Dominant and intermediate trees.			Dominant trees only.		
	Trees per acre.	Basal area.	Average diameter breast high.	Trees per acre.	Basal area.	Average diameter breast high.	Trees per acre.	Basal area.	Average diameter breast high.	Trees per acre.	Basal area.	Average diameter breast high.
Years.	*No.*	*Sq. ft.*	*Inches.*	*No.*	*Sq. ft.*	*Inches.*	*No.*	*Sq. ft.*	*Inches.*	*No.*	*Sq. ft.*	*Inches.*
20	1,580	115	3.6	.....	.....	.....	1,294	102	3.8	489	54	4.5
25	1,295	142	4.5	102	20	6.0	1,076	140	4.9	466	80	5.6
30	1,110	168	5.3	187	47	6.7	887	169	5.9	447	106	6.6
35	980	193	6.0	267	77	7.3	756	190	6.8	432	129	7.4
40	882	216	6.7	345	114	7.8	668	205	7.5	420	150	8.1
45	808	237	7.3	419	157	8.3	603	216	8.1	410	167	8.7
50	752	256	7.9	462	195	8.8	558	225	8.6	402	183	9.1
55	707	272	8.4	480	222	9.2	527	232	9.0	395	195	9.5
60	668	286	8.8	487	241	9.5	506	238	9.3	388	206	9.9
65	640	298	9.2	490	256	9.8	490	242	9.5	383	215	10.2
70	620	308	9.5	491	268	10.0	478	247	9.7	378	223	10.4
75	603	317	9.8	490	278	10.2	467	250	9.9	373	230	10.7
80	590	325	10.1	489	287	10.4	457	253	10.1	368	236	10.8
85	579	332	10.3	487	294	10.5	447	256	10.2	363	240	11.0
90	568	338	10.5	485	301	10.7	437	259	10.4	359	245	11.2
95	558	344	10.7	483	308	10.8	427	262	10.6	355	249	11.3
100	549	349	10.8	481	313	10.9	417	264	10.8	351	252	11.5

QUALITY II.

20	1,996	98	3.0	.....	.....	.....	1,603	84	3.1	566	40	3.6
25	1,520	120	3.8	.....	.....	.....	1,316	115	4.0	530	60	4.6
30	1,285	142	4.5	.....	.....	.....	1,062	139	4.9	504	81	5.4
35	1,142	162	5.1	260	58	6.4	890	157	5.7	484	101	6.2
40	1,032	182	5.7	335	88	7.0	774	171	6.3	470	119	6.8
45	949	199	6.2	403	122	7.4	697	181	6.9	459	136	7.4
50	880	215	6.7	467	155	7.8	643	189	7.4	451	151	7.8
55	830	229	7.1	497	180	8.1	605	196	7.7	443	162	8.2
60	789	242	7.5	516	199	8.4	575	201	8.0	435	172	8.5
65	756	253	7.8	530	214	8.6	551	206	8.2	427	181	8.8
70	732	262	8.1	540	226	8.8	532	210	8.5	420	188	9.1
75	708	270	8.4	544	235	8.9	516	213	8.7	413	194	9.3
80	689	278	8.6	544	244	9.1	503	216	8.9	407	200	9.5
85	672	284	8.8	542	251	9.2	492	220	9.0	401	205	9.7
90	656	290	9.0	540	257	9.3	482	223	9.2	395	209	9.8
95	642	295	9.2	537	263	9.5	472	226	9.4	390	213	10.0
100	632	300	9.3	533	268	9.6	463	228	9.5	385	217	10.2

QUALITY III.

20	2,803	81	2.3	.....	.....	.....	2,134	67	2.4	678	27	2.7
25	1,870	98	3.1	.....	.....	.....	1,620	90	3.2	623	42	3.5
30	1,540	115	3.7	.....	.....	.....	1,304	109	3.9	580	57	4.3
35	1,357	131	4.2	.....	.....	.....	1,074	124	4.6	548	73	5.0
40	1,224	147	4.7	311	61	6.0	924	136	5.2	526	90	5.6
45	1,129	161	5.1	386	89	6.5	827	145	5.7	514	105	6.1
50	1,055	175	5.5	455	115	6.8	755	153	6.1	505	119	6.5
55	996	187	5.9	515	138	7.0	703	159	6.4	496	129	6.9
60	945	198	6.2	549	156	7.2	664	164	6.7	488	138	7.2
65	903	208	6.5	572	171	7.4	634	168	7.0	480	146	7.5
70	866	216	6.7	587	183	7.6	609	172	7.2	472	153	7.7
75	838	224	7.0	597	193	7.7	588	176	7.4	464	158	7.9
80	813	230	7.2	606	201	7.8	569	180	7.6	457	164	8.1
85	790	236	7.4	602	207	8.0	551	183	7.8	450	168	8.3
90	772	242	7.6	596	212	8.1	533	186	8.0	443	173	8.5
95	760	246	7.7	588	217	8.2	516	189	8.2	436	177	8.6
100	750	251	7.8	589	222	8.3	499	192	8.4	430	181	8.8

Based on 59 sample plots, measured in 1910. Total area, 13.1 acres.

VOLUME GROWTH.

The increase in volume of trees growing in the virgin, or selection, forest is seldom considered on the basis of age for reasons already discussed under height and diameter growth. We are not much interested, for the present at least, in knowing how long it took, or would take again, to produce a spruce of a certain size under similar virgin forest conditions. Most lumbermen are desirous of knowing what can be expected of trees of given sizes for the immediate future. The conditions under which such growth is likely to take place will vary widely, so widely in fact that general tables of growth would be of little value. A local table made up to fit the special conditions of each case is much preferable. Such a table is readily prepared from volume or taper tables and the general data already presented.

In preparing a table of this kind it is usually assumed that a tree now 10 inches in diameter at breastheight will, when it has grown to a diameter of 11 inches, have the volume of the 11-inch trees with which it is at present associated. Diameter growth figures thus form the basis of the calculations. If the future growth of a virgin stand is to be forecasted, the diameter growth figures employed must be those derived from trees growing under these average conditions. Usually, however, an immediate partial cutting is contemplated. Whether the growth figures for the "average maximum" or "absolute maximum" should be used will depend upon the extent to which the cutting opens up the stand. Conditions would need to be exceedingly favorable to warrant using the "absolute maximum" figures of diameter growth. It might even happen that the "average maximum" would show too high results, particularly for forecasting results within the succeeding decade. Spruce does not respond immediately to an opening up of the crown cover. Intermediate trees of from 6 to 10 inches in diameter may not respond at all inside of 12 or 15 years.

The following example will suffice to show how these data are combined:

Suppose one desires to ascertain the probable volume of the 14-inch trees in an average stand of spruce in New York 15 years after a cutting to a 16-inch diameter limit. Assuming such a sized tree to be able to take full advantage of growth conditions and develop at the full "average maximum" rate, the annual increment in diameter would be, according to Table 10, 0.150 inch. In 15 years, consequently, it would have added 2.25 inches to its diameter and become a 16.25-inch tree. The average 14-inch tree, according to Table 4, is 62 feet tall and has a volume according to Table 9 of

136 [1] board feet. A 16.25-inch tree similarly is 66 feet tall and has a volume (interpolated) of 188 board feet. Thus the increased growth during the 15 years is 52 board feet, equivalent to 38 per cent. When the future yield of whole stands is to be computed a tabular arrangement of such values will be found convenient.[2]

Inch diameter class.	Corresponding height.	Corresponding volume.		Diameter.			Corresponding volume value from (4).[1]		
		Direct from volume table.	Values in (3) curved.	10 years hence.	20 years hence.	30 years hence.	10 years hence.	20 years hence.	30 years hence.
1	2	3	4	5	6	7	8	9	10
	Feet.	*Board ft.*	*Board ft.*	*Inches.*	*Inches.*	*Inches.*	*Board ft.*	*Board ft.*	*Board ft.*
8	47	34	31	10.2	12.5	14.7	61	107	162
9	50	43	43	11.2	13.4	15.6	77	128	188
10	53	55	58	12.1	14.2	16.3	97	148	209
11	56	82	75	13.0	14.9	16.9	118	167	227
12	58	97	95	13.8	15.7	17.5	138	191	245
13	60	120	118	14.7	16.4	18.0	162	212	260
14	62	130	143	15.5	17.0	18.5	185	230	278
15	64	150	170	16.3	17.6	18.8	209	248	288
16	66	200	200	17.1	18.2	19.3	233	267	306
17	68	230	230	17.9	18.9	19.8	257	291	324
18	70	260	260	.....	.....	.....	.....	.....	.....
19	71	290	295	.....	.....	.....	.....	.....	.....
20	73	320	331	.....	.....	.....	.....	.....	.....

[1] Interpolated.
It will be noted that in column 3 the values have not been interpolated, although they might well have been. Instead they have been read directly from the volume table and the irregularities evened off in column 4 by curving. The values in columns 8, 9, and 10 are interpolated from column 4 in order to eliminate the irregularity that would otherwise result from rounding off the diameter values in columns 5, 6, and 7 and reading direct from column 4. Curving of the values in 8, 9, and 10 may in some instances be necessary.

The figures contained in Tables 15 and 16 show the comparative development of spruce in the Adirondacks and West Virginia under "average maximum" growth conditions. Unfortunately, the data were insufficient upon which to extend the New York table above 120 years. An inspection of the height and diameter tables upon which this is based, however, shows the growth of each very much slackened. Inspection of Table 15 itself shows that the periodic annual growth culminated in the ninetieth year, while the mean annual would unquestionably culminate under 150 years. In West Virginia, on the other hand, the periodic annual growth does not begin to slacken until the one hundred and fiftieth year, while the mean annual growth continues unabated until the two hundred and fiftieth year.

[1] Under ordinary circumstances it would be sufficiently accurate to use the value corresponding to a 14-inch tree 60 feet in height which, according to Table 29, is 130 board feet. In computations of this sort however, the volume table values had better be interpolated so as to secure a closer reading. Thus, it may be assumed that if a 14-inch tree has a volume of 130 board feet when 60 feet tall and 160 board feet when 70 feet tall, when it is 62 feet tall its volume will be 136 board feet (130 (160-130) by 0.2).

[2] The tabular form indicates all the steps to be taken in making up such a table of values for red spruce in New York under "average maximum" growth conditions.

TABLE 15.—*Cubic volume growth of red spruce in the Adirondacks, N. Y. (For "average maximum" diameter growth conditions.)*

[CURVED.]

Age.	Diameter breast high.	Height.	Volume.	Periodic annual growth.	Mean annual growth.
Years.	*Inches.*	*Feet.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*
10	0.5	8	.....	.....	.....
20	1.3	13	.....	.....	.....
30	2.5	20	.....	.....	.....
40	4.0	29	.....	.....	.....
50	5.7	37	3.9	.....	0.078
60	7.8	46	8.0	0.41	.133
70	10.0	53	15.0	.70	.214
80	12.0	58	23.0	.80	.288
90	13.8	62	32.0	.90	.356
100	15.2	65	40.0	.80	.400
110	16.3	67	47.0	.70	.427
120	17.3	68	54.0	.70	.450

Dominant trees—spruce hardwood type.
This table is a combination of growth-diameter Table 10, height Table 4, and volume Table 40.
Data collected by the Conservation Commission of New York in 1912 in Essex and Herkimer Counties.

TABLE 16.—*Cubic volume growth of red spruce in West Virginia. (For "average maximum" diameter growth conditions.)*

[CURVED.]

Age.	Diameter breast high.	Height.	Volume.	Periodic annual growth.	Mean annual growth.
Years.	*Inches.*	*Feet.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*
10	0.9	10	.....	.....	.....
20	2.1	17	.....	.....	.....
30	3.5	25	.....	.....	.....
40	5.1	34	.....	.....	.....
50	6.8	44	4.7	.....	0.094
60	8.6	54	10.7	0.60	.178
70	10.5	64	19.0	.83	.271
80	12.5	73	30.0	1.10	.375
90	14.5	81	43 0	1.30	.478
100	16.4	87	60.0	1.70	.600
110	18.2	93	78.0	1.80	.709
120	19.9	97	96.0	1.80	.800
130	21.4	100	115 0	1.90	.885
140	22.8	103	134.0	1.90	.957
150	24.2	106	154.0	2.00	1.027
160	25.4	108	174.0	2.00	1.088
170	26.6	109	193.0	1.90	1.135
180	27.6	111	212.0	1.80	1.178
190	28.6	112	230.0	1.80	1.211
200	29.5	113	247.0	1.70	1.235
210	30.3	114	263.0	1.60	1.252
220	31.0	114	279.0	1.60	1.268
230	31.7	115	293.0	1.40	1.274
240	32.3	116	307.0	1.40	1.279
250	32.9	116	321.0	1.40	1.284
260	33.5	117	334.0	1.30	1.285
270	34.0	117	347.0	1.30	1.285

All trees—spruce slope type.
This table is a combination of growth-diameter Table 11, height Table 4, and volume Table 41.
Data collected by John Foley in 1903 in Greenbrier County.

While similar data are not available for either Maine or New Hampshire, a comparison of the "Lower spruce and hardwood" and even of the "Average-of-all-type" values of Maine (Table 9) with the "Average" values of New York (Table 10) indicates a better average development in Maine than in New York. Adequate figures for New

Hampshire would undoubtedly show somewhat better general development there than in Maine.

The growth in volume of trees in even-aged stands may be determined in a manner similar to that just described. In this case, however, the diameter growth instead of being calculated by arbitrary periods, such as 10 or 20 years, would be expressed in terms of total age. If the rate of volume growth is to be determined for natural stands undisturbed by thinnings or other treatment which would tend to interfere with the process of elimination by natural competition, the diameter growth should be based on the average growth of all green trees of the even-aged normal stands of different ages. If, however, thinnings are contemplated which will enable the trees composing a stand to grow at their maximum rate with the minumum of competition, the basis for growth should be the mean average of the dominant and intermediate (Table 12) or, under the most favorable conditions, the dominant trees only of the even-aged normal stands of different ages.

STANDS AND YIELDS.

The yield of virgin or selection growth spruce, both present and future, varies widely from one type to the other and within the same type in different regions. It is not possible under the circumstances to discuss the subject in such detail as to cover the full range of conditions which local variations impose, nor are the data available for such discussion. Given certain fundamental data, the range of reliability of which is less restricted than would be yield tables based on the widely variable conditions existing in our present virgin and cull spruce selection forests, the yield for any particular tract can be readily computed.

Aside from that already presented for the various regions under the headings of growth in height, diameter, and volume, the only information needed is the enumeration of the stands[1] the yield of which is to be determined and their average composition as to size and species calculated and tabulated for use in the following convenient form:

Diameter, breast high.	Average number of trees.			Spruce left to grow (average number).
	Spruce.	Other species.	Total.	
1	2	3	4	5
Inches.				

[1] In the appendix (Tables 50–53, inclusive, on pp. 94–97), will be found stand tables prepared from such enumerations in virgin forest growth of the spruce slope type. The associated species are included as a matter of comparison. Incidentally, these tables show in a broad general way the relative production per unit of area of the different regions which they represent. It must not be understood, however, that any claim is made that they show exact average conditions throughout their respective regions.

Having decided whether or not, during the period for which the future yield is to be forecasted, cutting will take place and in what amount, a volume growth table such as that outlined on page 41 would be prepared. If a cutting is contemplated, there should be indicated on the stand table, as column 5, the average number of spruce trees of the different diameters which will be left for future growth. The present yield per acre of the stand would then be determined by multiplying the values in column 2 of the stand table by those in column 4 of the volume growth table. The future yield would similarly be determined by multiplying the values in column 5 of the stand table by those in columns 8, 9, 10, etc., of the growth table.

The yield of second-growth stands may be arrived at in a manner similar to that just outlined. The more direct method, however, is to measure all the trees on sample areas in stands of typical development and known age. The height, diameter, volume, and all other data for each plot are determined separately; and these various data are finally combined into a table on the basis of the age of the trees and the site quality to which they belong. Such a table appears below for normally stocked second-growth stands measured in Maine, New Hampshire, and Vermont. This table is based on data collected in unthinned stands of spruce which have come up on formerly cleared lands. So far as concerns the production of cubic volume and correspondingly, of cordwood volume, these values represent approximately the maximum for their respective ages and site classes. The table is thus suitable for use without modification in predicting the future yields of stands maintained for the production of pulpwood.

TABLE 17.— *Yield of red spruce in old-field stands.*

[Based on the yield of dominant, codominant, and intermediate trees only.]

QUALITY I.

Age.	Trees per acre.	Basal area.	Average diameter breast high.	Height.	Yield per acre.[1]			Forest form factor.	Basis.[2]
Years.	*Number.*	*Sq. ft.*	*Inches.*	*Feet.*	*Bd. ft.*[3]	*Cu. ft.*[4]	*Cords.*[5]		*Plots.*
20	1,294	102	3.8	24	.....	.....	.....	.....	.....
25	1,076	140	4.9	31	.....	.....	.....	.....	1
30	887	169	5.9	36	.....	.....	.....	.....	.....
35	756	190	6.8	42	.....	.....	.....	.....	.....
40	668	205	7.5	46	15,200	3,660	31	.38	.....
45	603	216	8.1	51	19,700	4,500	40	.42	1
50	558	225	8.6	55	23,300	5,140	48	.42	2
55	527	232	9.0	58	26,200	5,600	55	.42	1
60	506	238	9.3	61	28,500	5,950	60	.41	4
65	490	242	9.5	64	30,500	6,240	64	.40	5
70	478	247	9.7	66	32,100	6,490	68	.40	1
75	467	250	9.9	68	33,500	6,700	70	.39	.....
80	457	253	10.1	70	34,800	6,890	72	.39	.....
85	447	256	10.2	72	35,900	7,050	74	.39	.....
90	437	259	10.4	73	37,000	7,180	76	.38	.....
95	427	262	10.6	74	38,100	7,300	77	.38	.....
100	417	264	10.8	76	39,100	7,390	78	.37	.....
									15

QUALITY II.

20	1,603	84	3.1	19	.....	.....	.....	.....	.....
25	1,316	115	4.0	25	.....	.....	.....	.....	.....
30	1,062	139	4.9	31	.....	.....	.....	.....	.....
35	890	157	5.7	36	.....	.....	.....	.....	1
40	774	171	6.3	40	10,700	3,000	23	.44	.....
45	697	181	6.9	44	14,100	3,770	31	.47	.....
50	643	189	7.4	47	17,100	4,320	38	.48	2
55	605	196	7.7	50	19,600	4,720	44	.48	5
60	575	201	8.0	53	21,700	5,050	48	.47	.....
65	551	206	8.2	55	23,500	5,310	52	.47	9
70	532	210	8.5	57	25,000	5,550	54	.46	8
75	516	213	8.7	59	26,200	5,750	57	.46	3
80	503	216	8.9	61	27,300	5,910	59	.45	.....
85	492	220	9.0	63	28,300	6,050	61	.44	.....
90	482	223	9.2	64	29,300	6,170	62	.43	.....
95	472	226	9.4	65	30,200	6,280	63	.43	.....
100	463	228	9.5	66	31,100	6,370	64	.42	.....
									28

QUALITY III.

20	2,134	67	2.4	14	.....	.....	.....	.....	.....
25	1,620	90	3.2	20	.....	.....	.....	.....	.....
30	1,304	109	3.9	25	.....	.....	.....	.....	.....
35	1,074	124	4.6	30	.....	.....	.....	.....	.....
40	924	136	5.2	34	6,200	2,330	15	.51	.....
45	827	145	5.7	37	8,600	3,000	22	.56	.....
50	755	153	6.1	40	10,900	3,500	28	.57	2
55	703	159	6.4	42	13,000	3,830	32	.57	.....
60	664	164	6.7	45	14,900	4,150	36	.57	4
65	634	168	7.0	47	16,500	4,390	39	.56	2
70	609	172	7.2	49	17,800	4,590	41	.55	5
75	588	176	7.4	50	18,900	4,760	43	.54	1
80	569	180	7.6	52	19,800	4,920	45	.53	1
85	551	183	7.8	53	20,600	5,050	47	.52	.....
90	533	186	8.0	55	21,300	5,170	48	.51	.....
95	516	189	8.2	56	21,900	5,260	49	.50	1
100	499	192	8.4	57	22,500	5,340	50	.49	.....
									16

[1] Yield from suppressed and dead trees ignored. See Table 53 for actual figures on which this yield table is based.

[2] Based on 59 plots, in even-aged old pasture stands; area 13.1 acres, taken in Oxford and Penobscot Counties, Me.; Coos, Grafton, and Sullivan Counties, N. H.; Caledonia and Windsor Counties, Vt.

[3] Trees 7 inches and over in diameter breast high; scaled by the New Hampshire Rule; top diameter inside bark, 6 inches, stump height, 1 foot.

[4] Trees 4 inches and over in diameter breast high; top diameter outside bark, 4 inches, stump height, 1 foot.

[5] Trees 6 inches and over in diameter breast high; top diameter outside bark, 5 inches, stump height, 1 foot.

TABLE 18.—*Norway spruce* [1] (*Picea excelsa*). *Normal yield table for northern and central Germany.*

QUALITY I.

Age.	Number of trees per acre.	Basal area.[2]	Average height.	Diameter of average tree.[3]	Yield per acre.[3]	Forest form factor.
Years.		*Sq. ft.*	*Feet.*	*Inches.*	*Cu. ft.*	
40	1,254	194.8	47.9	5.4	4,973	0.531
50	799	216.1	61.4	7.2	7,067	.533
60	557	231.5	72.4	8.9	8,798	.525
70	421	241.8	81.3	10.4	10,227	.520
80	340	250.7	88.6	11.8	11,425	.514
90	284	259.2	94.8	13.2	12,457	.507
100	247	266.7	100.0	14.4	13,367	.501

QUALITY II.

40	1,924	140.8	30.2	3.7	2,115	0.495
50	1,216	162.4	42.0	4.9	3,673	.534
60	840	178.9	52.2	6.2	5,059	.539
70	628	189.2	61.0	7.4	6,274	.539
80	500	200.0	67.9	8.5	7,317	.534
90	424	209.5	73.5	9.5	8,217	.528
100	380	217.7	78.4	10.2	8,960	.522

QUALITY III.

40	3,587	95.5	17.6	2.3	638	0.380
50	1,969	116.3	25.3	3.3	1,410	.479
60	1,270	131.3	33.3	4.5	2,403	.550
70	928	142.5	41.1	5.4	3,344	.571
80	750	152.2	47.2	6.2	4,161	.579
90	651	160.6	51.8	6.8	4,823	.580
100	597	167.3	55.4	7.3	5,352	.577

[1] From "Wachstum und Ertrag normaler Fichtenbestande," by Adam Schwappach. Berlin, 1890, as translated by H. S. Graves (pp. 417 and 418, Forest Mensuration, New York, 1906), revised on the basis of 3 instead of 5 quality classes.
[2] At 1.3 meters (4.27 feet) from the ground.
[3] Derbholz (top diameter of 2.76 inches outside the bark).

A comparison [1] of the values in Table 17 for red spruce with those of Table 18 for Norway spruce brings out the importance of good management in the development of stands. One of the first things to arrest the attention is the marked discrepancy between red spruce and Norway spruce in height and volume growth in Quality I. Even red spruce's advantage in having only its best growing trees included is insufficient to overbalance the deficiency in height. One's first impulse is to take this as confirming the widely accepted opinion that the growth qualities of red spruce are markedly inferior to those of Norway. Yet if that were so, the discrepancy would prevail throughout the three quality classes, which it does not do. It is considerably less marked in Quality II and disappears almost altogether in Quality III. To explain this difference, one must take into consideration the intensity of management of Norway spruce in the different quality classes. Thus, in Quality III, where Norway spruce was least intensively managed, thinnings began late, between

[1] In making the comparison it should be continually borne in mind (1) that the red spruce table is based on the measurement only of dominant and intermediate trees in 29 volunteer stands, whereas the other includes all green trees in 100 managed stands, four-fifths of which were artificially regenerated, and (2) that the utilization is not so close for red spruce as for Norway either in the top or at the stump.

the fortieth and forty-fifth year, and were light, about 2 trees in 7, or hardly more than the natural thinning which took place among the dominant and intermediate trees in the corresponding red spruce stands. The thinnings throughout, up to and including the one hundredth year, were in fact insufficient to make the number of trees the same in the Norway spruce stands as in the red spruce (dominant and intermediate trees) stands of corresponding age. Nevertheless, thinnings did accelerate the rate of growth somewhat, so that by the one hundredth year the whole Norway spruce stand, consisting of 98 more trees, very closely approximated the development attained by the red spruce dominant and intermediate trees. In the Quality II stands the effect of thinnings is more marked. Thinnings began in the thirty-fifth year, with an intensity of 3 trees in 7 removed (42 per cent), and continued comparatively heavy till the eightieth year, when they were 1 in 5 (20 per cent). The acceleration in this case is everywhere apparent. Shorter by 10 feet in the fortieth year, the whole Norway spruce stand had by the sixtieth year attained the same development as the dominant and intermediate red spruce stand of that age, and, while still lacking nearly 2 inches in average diameter, showed 9 cubic feet greater volume. By the eightieth year the total stems in the Norway spruce stand had been reduced to 3 less than the number of dominant and intermediate trees in the red spruce stand; had practically the same average diameter and 7 feet greater height; and being fuller boled, as indicated by the larger form factor, showed a very much accelerated volume growth. In Quality I, thinnings began in the twenty-fifth year on a scale slightly more than 3 in 7; and the entire stand with 586 more trees, had by the fortieth year surpassed in average height the average dominant and intermediate development of the red spruce stand of corresponding age and quality. This, with the fuller bole development, gave the Norway stand a considerable advantage in volume development, whether or not it accounts for all of the 1,313 cubic feet excess volume at that age. From that time on the red spruce stagnated and languished; but the Norway spruce, under the stimulas of frequent thinnings, increased steadily in every respect. The conclusion to be drawn from the comparison seems to be that lack of management rather than any inherent deficiency in growing qualities was the factor most largely responsible for the less ravorable showing of red spruce.

METHODS OF CUTTING.

The methods of cutting to secure the natural regeneration of spruce depend in a large measure upon whether the stand to be perpetuated is of the selection, or many-aged form, as represented by the virgin and the cull forests, or of the even-aged form, such as those coming in after fire or windfall, or on abandoned pastures.

SELECTION CUTTINGS.

On account of the tolerance of spruce, it is well adapted to a selection system of management by which only the older trees of the main stand are removed and the necessary conditions thus established for the development of a new young growth. When this system is strictly carried out, the forest should be cut over annually, and only the very oldest and largest trees and those of least promising growth removed. In forests constituted as ours are at present, such a procedure would be impossible of accomplishment under any other than State ownership, which might put other considerations above revenue.

Cutting to a diameter limit, now quite generally practiced by lumbermen in the spruce regions, is a modification of the selection system by which a sufficient yield to make the individual cutting operations profitable is secured periodically. The amount cut each period and the interval between the successive cuttings vary, of course, with the diameter limit used.

In order to obtain satisfactory results under this system, a careful scrutiny is required of those trees immediately above and below the set diameter limit that their relations to others and to the best interests of the stand to be left may be ascertained. A fixed diameter limit is used in making computations to forecast the yield; but its application by "rule of thumb" in actual practice may defeat the purpose of the system. In the woods the diameter limit is best used simply as a guide. In general the largest trees should be cut, since their rate of growth is below that which would make their retention a profitable investment. They are likewise occupying space which would be more profitably used by younger and more rapidly growing trees. Approaching the diameter limit there are trees both above and below the established limit which should be cut because they have a poor crown, are stunted, or otherwsie defective, so that their present worth would be lost if they were to be left until the next cutting. On the other hand, trees above the prescribed diameter limit which give every indication of being in thrifty growing condition should unquestionably be left, since their worth will be materially enhanced by allowing them to remain until the next cut is made. Trees of inferior species, as balsam and most of the hardwoods, which are interfering with the best development of the spruce, should be cut whenever possible.

Thus while the prescribed diameter limit may be 14 inches, the approximate minimum size to be taken may be 5 inches. Other things being equal, this minimum size will depend upon the market and the object of management. To insure a utilization of at least two-thirds of the stem height, no sound spruce tree should be cut for lumber smaller than 10 inches in diameter at breastheight and for pulp none smaller than 5 inches in diameter. These minima should

be raised to 11 inches and 6 inches, respectively, for stands averaging from 65 to 85 feet tall and to 12 inches and 6 inches for all stands over 85 feet tall.

It is not feasible to remove the defective trees which will not yield sufficient material to offset at least the cost of logging, except in localities where there is a high fire hazard or as a precaution against the spread of insects or fungous disease. In this case the logging operation may well be taken advantage of to improve fire protection or sanitary conditions by felling and swamping badly defective and dead trees and snags.

Care must be taken to provide suitable conditions for reproducing the stand. Where there is balsam in mixture with spruce, the competition of this species in the young growth should be reduced as far as possible by cutting the balsam in the main stand to as low a diameter limit as market conditions will warrant, thus reducing the number of balsam left for seed dispersal. Where the species in mixture are hardwoods, the same procedure will apply, although the elimination of the hardwoods need not be carried out so severely, for the reason that their effective range of seed dispersal is not so great as that of balsam. A more severe cutting of the hardwoods may be necessary, however, where there is much advanced young growth of spruce which requires to be released from shade to encourage its more rapid development.

Spruce should be favored in preference to balsam and most hardwoods for the reason that it is much less aggressive than the others and usually of the more value and desirability. Where conditions are favorable to the development of white pine and ash and possibly also basswood and red oak, they should be given the preference over spruce, since they are more valuable and less able to maintain themselves in competition with spruce, being less tolerant of shade.

It is impracticable to trust to the loggers to put the diameter limit into effect, and it is here that many spruce operators fail to secure the full benefit of the system's application. The trees to be cut should be marked beforehand by a man competent to judge the needs and requirements of the stand from the standpoint of both the forester and the operator. The fact that some companies which have tried marking claim that the results attained under the one method and the other do not materially differ does not prove the impracticability of the method, but reflects rather on the lack of trained judgment of the men whom they have employed to do the marking.

GROUPWISE CUTTINGS.

For general use the selection system in one of its forms is undoubtedly best suited to the management of spruce, particularly in lumber operations. Nevertheless it has its limitations. The degree of severity with which a stand must be cut to make the operation profitable

is important particularly in the swamp type and on the more exposed slope situations where there is great danger from windfall. In such situations the cuttings should be very light, so that the main crown cover will continue relatively undisturbed, or everything merchantable on a given area should be cut. This will virtually amount to clean cutting, for the nonmerchantable material left will almost inevitably be blown down.

If the individual cutting area is small, of only one or two acres in extent, and flanked by spruce growth either on its windward side or above it, reseeding from trees standing on the adjacent area will take place following clean cutting. Thus on a level, low-lying area groups or patches of timber may be selected for removal and the surrounding uncut areas depended upon to furnish the necessary seed for reproduction. In such a case subsequent cuttings would extend these areas gradually until the whole was cut over.

The exact shape and size of the area to be clean cut, as well as the selection of the initial points of attack in starting a groupwise cutting, depend on circumstances and the object it is desired to attain. Areas of advanced young growth may occur under the old woods, which it is desirable to free from shading and allow to develop; advantage may be taken of groups of overmature or insect-infested trees which are stagnating or declining in growth and value and which require cutting to prevent loss; or it might be desired to replace groups of mixed spruce and hardwoods by pure spruce, or to make an opening to encourage pine, ash, or other more valuable species.

The chief objection to this method in practice is that to insure effective reproduction the cleared areas should not exceed from 100 to 150 feet across. These should be separated by a sufficient amount of uncut timber to protect the cleared area from too severe exposure to sun and wind and insure the remaining stand against being blown down. For economical lumbering, however, a larger area would often be desirable.

CLEAN CUTTING IN STRIPS.

A better method for extensive cuttings in areas susceptible to windthrow is to distribute the clean cutting in strips in such a manner that the long way of the strip is at right angles, or nearly so, to the direction of the prevailing storm winds. Reproduction of the cleared areas would be secured by seeds disseminated from the trees in the intervening uncut timber belts which should be left intact at the time of the first cutting, or only very lightly thinned by removing small, or overtopped and dying trees without disturbing the main crown cover. Whether it is advisable to thin or not depends upon the degree of liability to windthrow, and upon the depth of the strips in the direction of the prevailing high winds. Instead of the sides of the strips in the cutting area being straight, they may be undu-

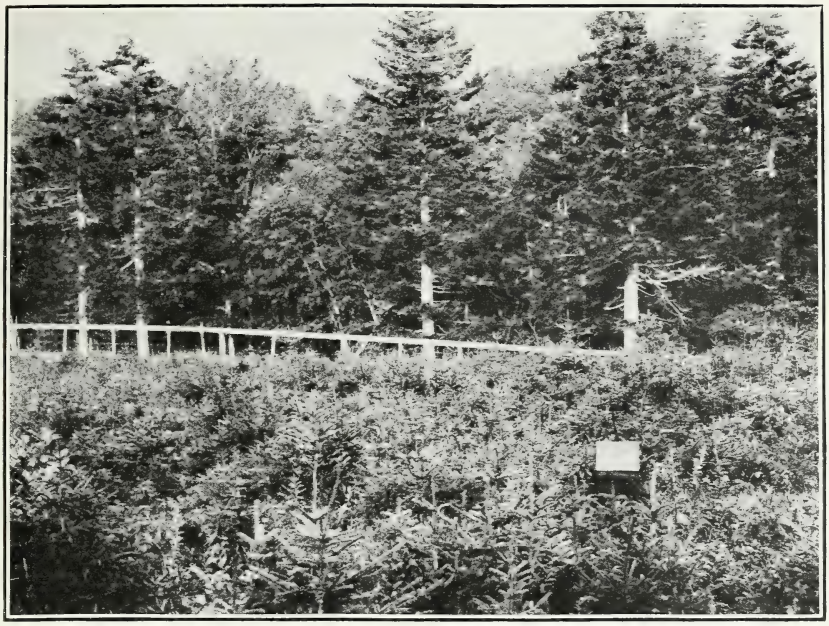

FIG. 1.—SEED TREES NEAR AT HAND. STOCKING DENSE IN CONSEQUENCE.

FIG. 2.—SEED TREES AT A DISTANCE. STOCKING IN GROUPS AND AS WIDELY SCATTERED INDIVIDUALS.

GENESIS OF OLD FIELD SPRUCE STANDS.

FIG. 1.—CLEAN CUT STRIPS 10 FEET WIDE AND RESERVE STRIPS 20 FEET WIDE (APPROXIMATELY); 38 PER CENT (13 CORDS) OF THE VOLUME REMOVED.

FIG. 2.—THE SAME CUTTING (NOT THE SAME ALLEY) AFTER 7 YEARS. GOOD SPRUCE AND BALSAM REPRODUCTION UNDER THE LIGHT COVER OF SEEDLING HARDWOODS.

STRIP CUTTING IN OLD FIELD SPRUCE.

lating or saw-toothed, like a series of wedges or triangles with their bases on line. This modification is rather commonly used with spruce abroad.

Effectiveness in securing reproduction with the strip plan will depend upon the width of the strips employed. Satisfactory restocking of the cleared area can not be expected on a strip wider than twice the height of the trees in the adjacent stand; not because of inability to secure effective seed dispersal at even a great distance, but because of the effect upon seed germination and growth. Too extensive cutting will expose the soil to drying influences detrimental to spruce reproduction and at the same time create a condition favorable to the development of hardwoods, raspberry, and other perennials and weed growth in general.

Satisfactory reproduction in the reserve strips must be secured as advanced growth from seed trees standing on those strips, or the cutting of the reserve strips must be delayed until the trees on the strips first cleared are large enough to supply the necessary seed. A spruce stand in which windfirmness has been especially developed by periodic thinning from early youth may be reproduced by the shelter-wood compartment method. Such stands, however, can hardly be said to exist in this country at the present time. Thinnings of the severity of shelter-wood cuttings are largely out of the question in the previously unthinned stands of either virgin or old-field spruce which it is desirable to manage under a system of clean cutting in strips.

To insure an early second cut and prompt and effective regeneration, alternate cut and uncut strips not over 75 feet in width should be employed. By the adoption of strips of this width reproduction would not only be reasonably assured to the cleared strips but the side light and extra ventilation which would be let into the uncleared strips would be sufficient to create a condition favorable to satisfactory reproduction there also. For the dense, even-aged, old-field stands, strips as narrow as 10 feet with 20-foot reserve strips intervening have been recommended.[1] The final clearing of the area under such a system should be possible within 10 or 15 years after the first cut. This will enable the harvesting of a third or more of the crop at one cut. The cost will of course be somewhat more than if wider strips or clean cutting in a solid block were practiced. The yield and operating cost per unit of area should not, however, be materially different from that which would result from cutting to a diameter limit of 14 inches, except that slightly greater expense would attach to the handling and marketing of the smaller material which the clean cuttings would yield.

[1] "Forestry in New England," by R. C. Hawley and A. F. Hawes, p. 226.

The use of strips up to 300 feet wide or more will reduce the cost of logging but will delay the cutting of the second half of the area until the trees on the first half become large enough to furnish the necessary seed for reproducing it when cut over. This will delay the second cut to between the sixtieth and seventy-fifth year and require a rotation for each half of the stand of from 120 to 150 years. Complete stocking on the entire 300 feet of clearing could hardly be expected short of 3 and possibly 4 seed years; that is, from 15 to 18 years. Birch, aspen, beech, maple, and other hardwoods, and raspberries and other perennials will almost surely come in during the interval, whether the area is burned over or not. Spruce, however, will seed in beneath; and while that which comes in first where the cover crop is dense will be retarded, that which comes in later will find conditions favorable to its rapid development, so that when the overwood thins out, this understory of spruce will develop largely as an even-aged stand. (See Fig. 2a.)

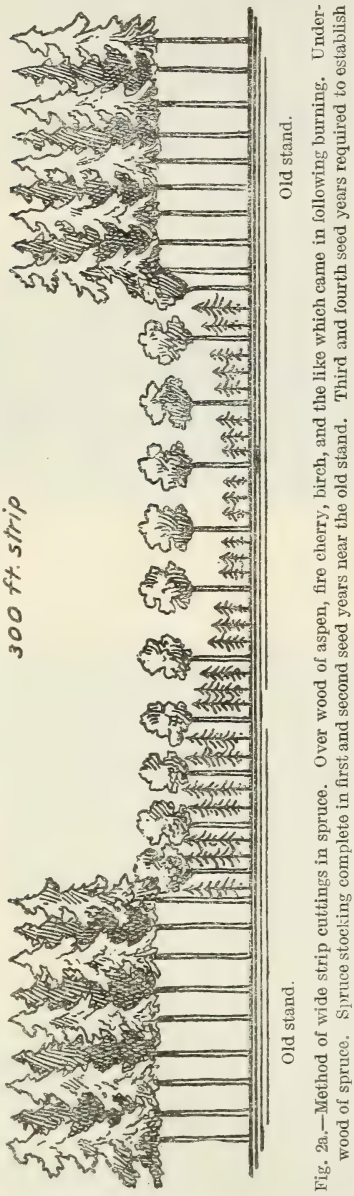

Fig. 2a.—Method of wide strip cuttings in spruce. Over wood of aspen, fire cherry, birch, and the like which came in following burning. Underwood of spruce. Spruce stocking complete in first and second seed years near the old stand. Third and fourth seed years required to establish satisfactory reproduction near the center of the strip.

The most desirable of the hardwoods as a nurse tree for spruce is the aspen. It also reaches such a size as to enable it to be cut at a profit within from 40 to 50 years. Its coming in, therefore, should be encouraged. This can best be accomplished by the broadcast burning of the brush in the early spring following the logging. The seed of fire cherry is dispersed in the summer and of beech, paper birch, and sugar maple in the fall and winter, while that of the aspen is dispersed in the early spring. Broadcast burning in the spring, therefore, as soon as the brush is dried out enough to burn readily, will destroy the duff and the seeds and spring germinates of the other

species and will expose mineral soil most opportunely for aspen seed to catch and take possession of the ground, followed by spruce in subsequent seed years.

This method should prove satisfactory, particularly where spruce saw timber is desired. The early growth of the main stand under the cover crop would prevent the development of stout branches to such a height at least that one or more clear logs to each bole could be produced. The cover crop would reach merchantable size by about the fortieth or fiftieth year and could be harvested. (See Fig. 2b.) The main crop could be thinned at the same time to secure satisfactory distribution of the trees to be left. With the removal of the cover crop all spruce would be stimulated and rapid development follow. At the time of clean cutting the second area, in from the sixtieth to seventieth year, it would be profitable to thin the stand again on the first area. (Fig. 2c.) The final thinning of the first area would take place between the one hundredth and one hundred and twentieth year, when the removal of the cover crop and first thinning of the second area was made, thus at least three thinnings of the spruce would be possible with little or no additional expense. The cost of bringing the cut of spruce to maturity would be somewhat more under this lengthened rotation than under a shorter rotation, but this would be offset to a considerable extent by the intermediate revenues from the harvesting of the cover crop and the thinnings and by the better quality of timber yielded. The method could obviously only be employed where there was an available market for the products yielded by the cover crop, namely, aspen pulp and excelsior stock, and maple

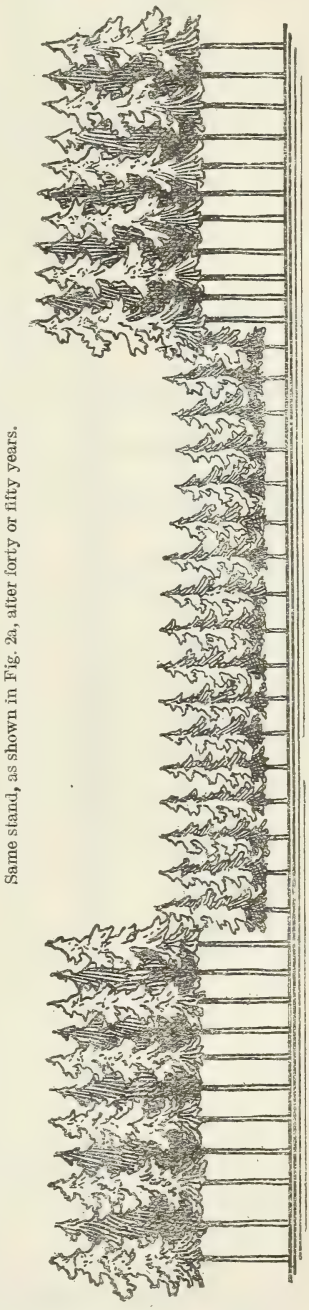

FIG. 2b.—Cover crop of aspen, fire cherry, etc., harvested, and spruce young growth thinned.

and birch firewood, spools, novelties, and the like. A permanent market for spruce of the quality produced would also be necessary.

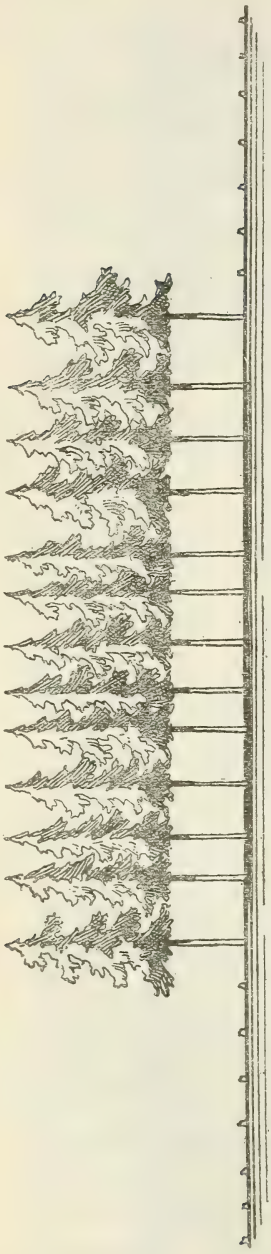
Same stand, as shown in Fig. 2a, after sixty or seventy years.
Alternate strips clean cut and burned.
Alternate strips clean cut and burned
Stand of seed bearing age by which means the alternate clean cut strips will be reproduced.

FIG. 2c.—Second thinning at time of clean cutting alternate strips.

IMPROVEMENT CUTTINGS.

With forests of the selection or many-aged form, thinnings, strictly speaking, merge to such an extent with the operations of harvesting the mature crops as to lose their identity. Thinnings and like operations, therefore, are applied to such forests only as are even-aged throughout or are made up of even-aged groups.

Improvement cuttings are divided successively into the following classes: cleanings, liberation cuttings, and thinnings. Pruning is also an improvement operation, but in this country, and particularly in the case of spruce, will be scantily employed. Pruning involves a direct investment of money from which only an indirect benefit is derived. With a short rotation, pruning makes possible the securing of a larger percentage of clear logs capable of yielding upper grades of lumber. Aside from so-called "fiddle butts" for piano board and violin stock and clear logs for siding material, the difference in price at the present time between the various grades of spruce will not justify an investment for pruning.

Cleanings.—Cleanings are particularly adapted to bring about favorable results in the mixed spruce and hardwood growths which come in after clean cutting and burning. Such worthless material as fire cherry and the slow-growing beech and sugar maple may be removed from young stands, and the birch and popple thinned. The most advantageous time is about the fifth year after the spruce has come in under the hardwood cover, since at that age spruce has fully established its roots in the mineral soil and is ready to grow rapidly in height. Cleanings may also be resorted to in old-field

spruce stands to eliminate spruce or balsam advance growth and to reduce the percentage of balsam in the stand. Cuttings of this sort are indirectly remunerative, in the sense that they operate to shorten the rotation and thus bring the final yield nearer at hand; but care must be taken to remove only what is necessary to accomplish the purpose of the operation, otherwise the cost will be too great.

Liberation cuttings.—In the mixed selection stands, it often happens that a large spreading maple or other hardwood is retarding the development of a group of young spruce. The removal of such a tree for that reason would be a liberation cutting. It will generally happen, though, that immediate financial considerations as to whether or not the tree is worth cutting will govern, and that such a cutting will be made a part of the regular logging operation. Similarly the removal of this class of tree from second growth stands will form a part of the operation of thinning. Because such trees are larger than the others in the stand, their removal may constitute a determining factor in making a thinning profitable. A liberation cutting will not often be made alone, although in certain instances it will justify itself by making possible a large final yield.

Thinnings.—Thinnings are particularly desirable in the dense, even-aged stands resulting from natural seeding. Such stands not infrequently have upwards of 4,000 trees per acre, with an average growing space of about 10 square feet per tree at 30 years of age. As compared to this, a planted stand spaced 6 by 6 feet apart would have but 1,210 trees per acre, with a growing space per tree of 36 square feet. Even where the aggregate number of trees in the natural stand is less than that indicated, the tendency of spruce to germinate in clumps about the more favorable seed bed spots gives rise to a crowding which is every bit as undesirable as though the area were uniformly congested.

On account of the extreme tenacity with which spruce hangs on when once it has its roots established in the soil, it is not able to free itself in the struggle for supremacy with anything like the facility of the less tolerant species. As a result, a long period of stagnation, in which both the height and diameter growth suffer, follows the closing of the crown cover. These stands, if allowed to continue in their overcrowded condition until they are from 50 to 60 years of age, will often contain as many dominant and intermediate trees to the acre as the planted stand would have to start with, and will be composed of small-topped, spindling trees, averaging not more than 6 or 7 inches in diameter; and not more than one-half of the total volume will be merchantable. Under such conditions, also, the stand can not be thinned profitably. The cost of getting out the amount of product to be secured from a first thinning in such a stand

would be prohibitive. The remaining trees would be particularly liable to windthrow, and the thinning would produce doubtful results in securing an accelerated growth. With the attainment of their principal height growth, the trees composing a crowded stand have adjusted themselves through the abnormal reduction of their crown surface to the restricted growing space, and the possibilities of stimulating the growth in such a stand are not promising, unless the stand is to be left intact for upwards of 30 years afterward.

The principle to be followed in making thinnings depends upon the object of management and the age when thinnings can be begun. If it be desired to secure the maximum volume production, which culminates, according to Table 14, between the thirty-fifth and seventieth year, depending on the unit of volume and the site quality, thinnings should be undertaken by the twenty-fifth or thirtieth year on the best sites and be confined to the dominant and intermediate trees. If, however, quality production is the object desired, the first thinnings may be delayed until the thirty-fifth or fortieth year, being confined to the lower and intermediate crown classes until the sixtieth or seventieth year. This would especially encourage the development of form and quality. Thereafter the stand would be thinned more heavily. The last third of the rotation, or approximately after the eightieth or the one hundredth year, the cuttings would be in the form of accretion cuttings which would isolate a certain number of the best trees for the encouragement of a more rapid growth in volume.

The object of thinnings for volume production should be to free the tallest trees and gradually reduce their numbers without removing the weakest, except where they have a dry top, since they assist natural pruning, cover and protect the soil, and add to the strength of a close canopy. In the early period, when the trees are only to a limited extent merchantable, the fewest number of trees possible should be removed. The greatest advantage, accordingly, can be derived by cutting only those trees which occupy a position in the upper crown level, but which are interfering with the development of the stronger growing individuals. This will relieve the intense struggle taking place among those trees which are finally to form the mature stand and will allow them to develop with a minimum of hindrance from their neighbors. To be most effective, thinnings should be frequent and light in early life and heavier and less frequent in later years. Such early thinnings, however, involve a considerable expense, while the later ones may render the stand liable to windthrow, so that it will often be necessary to compromise.

In judging of the need for thinning, the relation of the crown length to the total height of those trees which are to form the final cut should

be noted. This would ordinarily vary between 25 and 40 per cent, depending on whether maximum solid volume or board-foot volume was the desired object. However, the response to thinnings made in spruce having an average crown length of less than 25 per cent of the height will be exceedingly slow and for that reason of doubtful financial value.

In Table 19 an attempt is made to predict the yield due to accelerated growth to be obtained by thinnings made at different ages and with varying degrees of severity.

TABLE 19.— *Yield from stands of average quality thinned for maximum volume production of pulpwood (unpeeled cords) based on the cutting of dominant (including codominant) and intermediate trees only. Minimum merchantable size, 6 inches in diameter at breastheight and 5 inches in diameter outside bark in the top.*

4 THINNINGS.

Age of stand.	Number of dominant and intermediate trees.			Proportion of trees removed.	Merchantable volume of trees removed.	Final yield.	Total yield.	Equivalent mean annual growth.
	In fully stocked unthinned stands.	To be left after thinning.	To be removed in thinning.					
1	2	3	4	5	6	7	8	9
Years.					*Cords.*	*Cords.*	*Cords.*	*Cords.*
25	1,316	1,097	220	1/6				
30	1,062	914	183	1/6	4.9			
35	890	762	152	1/6	5.6			
40	774	635	127	1/6	7.4			
			682		17.9			
45	605					44	61.9	1.37

3 THINNINGS.

25	1,316	1,054	263	1/5				
35	890	791	263	1/5	7.1			
45	697	593	198	1/5	9.5			
			724		16.6			
50	605					44	60.6	1.21

2 THINNINGS.

30	1,062	849	212	1/4				
40	774	637	212	1/4	10.2			
			424		10.2			
50	605					44	54.2	1.10

The basic values are taken from Table 17, giving the yields for unthinned, fully stocked, old-field spruce stands of second quality. The volume production of these stands reaches a maximum in the fifty-fifth year and is 44 cords per acre. The assumption is made in Table 19 that 4 thinnings will reduce the natural rotation 10 years;

while for 3 and 2 thinnings 5 years will be saved in bringing the stand to maturity. The severity of each thinning is gauged so as to leave approximately the same number of trees as are shown by the yield table to be capable of growing under naturally competitive conditions at the end of the thinning period. Thus, in the case of the series of 4 thinnings, the first one in the twenty-fifth year reduces the number of trees from 1,316 to 1,097, which not quite approximates the condition which would be brought about by natural selection in the succeeding 5 years. The normal number of trees in unthinned stands (column 2) does not enter into the calculation but is included only for comparison to show how far each thinning will eliminate competition during the period.

All first thinnings, according to the table, show no remunerative yield. They are accordingly made light to reduce as far as possible the expense involved in making them. The maintaining of a reasonable density is also a consideration in making the thinning light, thus improving the form and quality of the final yield. With four thinnings the number of trees is not sufficiently reduced in any one thinning so that a normal density will not be restored within 5 years. With the 3 thinnings the number of trees is reduced in each case somewhat below the normal for a fully stocked stand of 5 years greater age. For example, the first thinning at 25 years reduces the number of trees to 1,054, while the normal density for 30-year stands is 1,062. With 2 thinnings the cut is heavier still. In each case, however, there is little doubt that the crown cover will be reestablishd in 5 years.

In calculating the volume of each thinning the volume of the average tree in the yield table has been taken as a basis. The assumption introduces a plus error, since doubtless the average of the trees taken out will not in all cases be the same as the average of the stand. Yet any error which may arise from this cause will be more than offset by the fact that in addition to the indicated number of dominant and intermediate trees taken an unestimated amount will be yielded by suppressed and dead trees taken at the same time. The final yield also is based exclusively on that to be obtained from dominant and intermediate trees, while the suppressed and dead will doubtless yield several cords additional at the final cutting.

In the absence of graded mill tallies for second-growth spruce it is not possible to determine the rotation yielding the highest quality increment. Table 20, however, attempts to show the intermediate and final yield in board feet for spruce which has started under a light hardwood cover and been managed under the wide strip system outlined elsewhere.

TABLE 20.—*Yield from stands thinned for production of superior quality lumber, based on the cutting of dominant (including codominant) and intermediate trees only. Minimum merchantable size, 7 inches in diameter at breastheight and 6 inches in diameter outside bark in the top.*

Age of stand.	Number of dominant and intermediate trees only.			Proportion of trees removed.	Merchantable volume of trees removed.	Final yield.	Total yield.	Equivalent mean annual growth.
	In fully stocked unthinned stands.	To be left after thinning.	To be removed in thinning.					
1	2	3	4	5	6	7	8	9
Years.					*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*
45	1,316	1,053	263	$\frac{1}{5}$				
55	890							
65	697	514	129	$\frac{1}{5}$	3,870			
75	605							
85	551							
95	516							
105	492	347	116	$\frac{1}{4}$	7,775			
115	472							
					11,645			
120	463					25,630	37,275	310

It has been assumed in this case that at the time of removal of the hardwood cover, in the forty-fifth year, the understory of spruce would have a development parallel to that of a 25-year-old stand which had started in the open. Thus by adding 20 years to the different ages given in Table 17 the equivalent yields in unthinned stands up to 120 years are obtained.

The first thinning is indicated to be light and unremunerative, but there would doubtless be yielded at least a small amount of cordwood, which would be the class of material chiefly yielded by the cover crop of aspen, birch, and other hardwoods taken out at this cutting. The cut, as a whole, should therefore show a fair profit. This thinning would reduce the number of dominant and intermediate trees in the stand to a spacing of about 7 by 6 feet or that found in a normal unthinned stand seven years older, although the cover would doubtless entirely close in five years or less. The relief from competition should, however, occasion such an acceleration in growth for the 20-year period before the next thinning as to gain 5 years over the unthinned stand. Thus the stand at the next thinning, in the sixty-fifth year, would have the development shown for 70-year-old unthinned stands, or 643 dominant and intermediate trees to the acre.

From the sixty-fifth year on to the one hundred and fifth year, when the third thinning would take place, the reduction in numbers in natural unthinned stands is very gradual, 54 between the seventieth and seventy-fifth years, and but 11 between the one hundredth and one hundred and fifth years. The removal of one tree in five from the dominant and intermediate crown classes at the sixty-fifth year would consequently reduce the number of stems to that

found in a fully stocked unthinned stand of 95 years. The means this thinning would afford for the enlargement of the crowns of the remaining trees should make it possible to sustain such a rate of growth for the 40-year period as would bring the thinned stand at 105 years to a state of development equal to the unthinned 120-year-old stand. This would require a periodic mean annual growth of but 350 board feet, which should be easily possible, since in the unthinned stands it is 500 board feet per annum for the period from the seventieth to the seventy-fifth years and 360 board feet per annum from the eightieth to the eighty-fifth, with a mean for the 40-year period of 280 board feet per annum.

The final thinning in the one hundred and fifth year would be increased in severity so as to take out 1 tree in every 4 in the dominant and intermediate crown classes, thus reducing the number of trees remaining in these classes to 347 and the volume to 23,300 board feet in round numbers.

The calculation of the final yield is based on the assumption that the volume will increase at the same rate per cent in the final 15 years in the thinned stand as in the unthinned stand. This gives an average volume for the 347 trees of 74 board feet per tree, corresponding to a tree 9.5 inches in diameter at breast height and 65 feet tall, which is well within the limits of reason.

These calculations, like those on cord yields, leave out of consideration entirely all intermediate or final yields to be obtained in cutting suppressed and dead trees, which in the aggregate would be considerable, thus making the predictions amply conservative.

Doubtless on the rotations after the first one, except in exposed situations, the final removal of the crop might be begun in the ninety-fifth or one hundredth year under the shelter-wood compartment method. This would render the two cutting areas suggested in the original plan independent of one another, so far as seeding was concerned; would eliminate the intermediate hardwood crop, and would enable the rotation to be materially shortened. In such a case it might be well to introduce another thinning about the eighty-fifth year. A too-intensive system of management, however, for the production of first quality spruce sawlogs will not be justified. Competition with white pine similarly managed would make such an undertaking entirely unprofitable.

Figure 3, based on actual measurements in old-field spruce stands, shows graphically the influence the number of trees per acre has upon the development of the stand, particularly on average breast-high diameter and yield.

Overcrowding in plot 39 is particularly apparent from the underdevelopment of breast-high diameter and of board-foot contents. In contrast with this is the understocking in plot 17, which gave rise

to an abnormal diameter development as well as of board-foot contents and a less-than-normal cubic and cord volume. The full effect of understocking is obviously obscured by the better-than-average height development of plot 17, which amounts to more than 10 feet above the average and would occasion a 12 to 15 per cent increase in volume. The subnormal total basal area is the best index in this case. As is to be expected, the overstocked stand, plot 39, shows a maximum cubic and cord volume. Plot 46 illustrates very well the benefits to be derived from a slight understocking such as would be

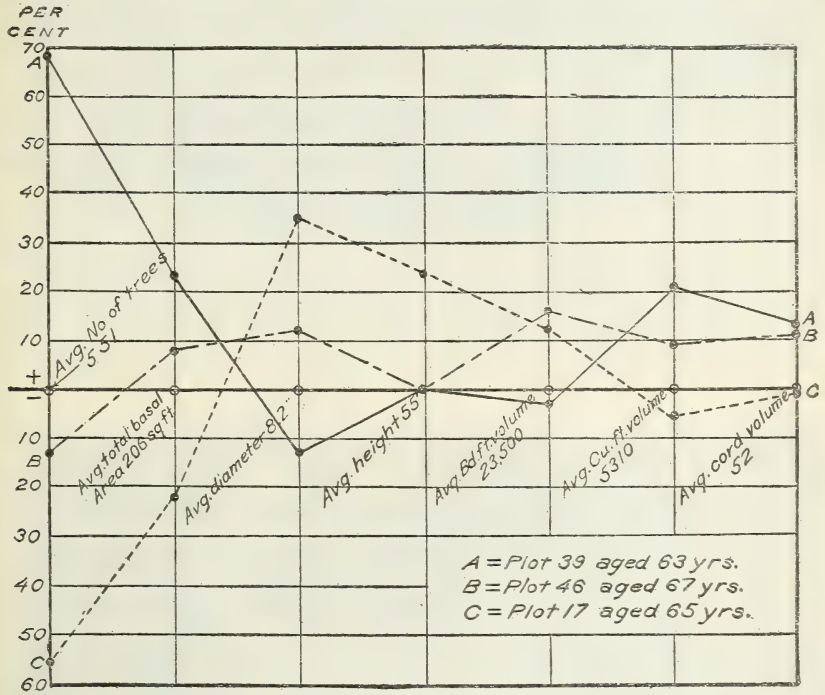

FIG. 3.—Effect of stocking on yield. Comparison of actual measurements of sample plots approximately 65 years old, with the average measurements for a 65-year-old stand in the second growth yield table. All stands Quality II and measurements are for dominant (including codominant) and intermediate trees only. Plottings are in percentages of the normal or average values of the different factors.

brought about by thinning. Thus, with a normal height growth a 13 per cent understocking was accompanied in this instance by increases of 8 per cent in basal area, 12 per cent in average diameter, 16 per cent in board-foot yield, 9 per cent in cubic-foot yield, an 11 per cent in cordwood yield.

BRUSH DISPOSAL.

One of the most potent sources of danger to spruce forests in general is the brush and, more particularly, the lops or branch wood which litter the ground after logging. The culled logs and tops from which the branches have been lopped do not of themselves constitute a

material source of danger, provided they are brought into contact with the soil and rapid decay thus induced. Spruce branch wood, however, on account of its resinous character, is particularly inflammable and resistant to decay, and constitutes a fire menace for several years when unlopped and from 7 to 10 years when lopped. In the forests where spruce is the predominating species, and particularly in the dense second-growth woods, an enormous quantity of such branch wood litters the cutting area. The ground is likewise covered with a dense mantle several inches in depth of dry needle litter, small twigs, and old cones. All this débris when exposed to the action of sun and wind with the cutting off of the forest cover, is quickly dried out and remains for several years an acute fire menace. The excessive branch-wood litter following lumbering and the deep humus cover also greatly hinder spruce reproduction on such areas and help the hardwoods and balsam to take possession through their superior ability to force their way to mineral soil.

When the selection system or other partial clearance cuttings are used or where the present age of spruce to be cut is not great, and where also a subsequent cut is dependent upon the maturing of seedlings or small trees which are on the ground at the time of the first cutting, the disposal of brush by burning is ordinarily not necessary unless the cut-over area is one on which there is special danger of fire getting a start.

BRANCH WOOD LOPPED AND SCATTERED OR PILED.

If only a little brush is produced and the fire danger is remote, the brush from the carefully lopped tops may be scattered about over the ground, thus hastening its decay. This method has given satisfaction where it has been tried in certain instances in the Adirondacks at a cost of from 15 to 25 cents per thousand board feet of lumber cut. Where more brush is produced than can safely be disposed of in this manner, the tops should be lopped and the branch wood piled. This will bring the larger material in contact with the soil, thus hastening decay. The segregation of the more inflammable material in compact bodies will reduce to a minimum the hindrance to reproduction and will effect a corresponding reduction in the danger from a rapid spread of fire should one start on the area.

BRUSH BURNED AS LOGGING PROCEEDS.

Excessive amounts of brush such as arise from the clean cutting of dense pure stands should be disposed of by burning. The most economical means of doing this is to burn the brush as the logging progresses. This is feasible when the ground is covered with snow or is damp so as to prevent the spread of fire. Small fires are started near each cutting crew and as the trees are felled the branches are lopped by the swampers and thrown into the fire. As the cutting

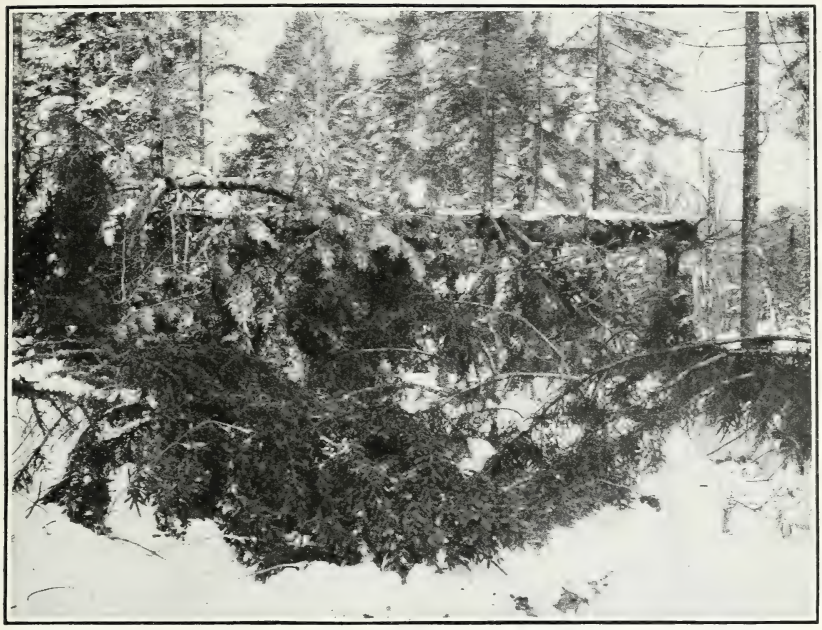

FIG. 1.—AN UNLOPPED TOP. A FIRE MENACE FOR FULLY 15 YEARS AFTER CUTTING.

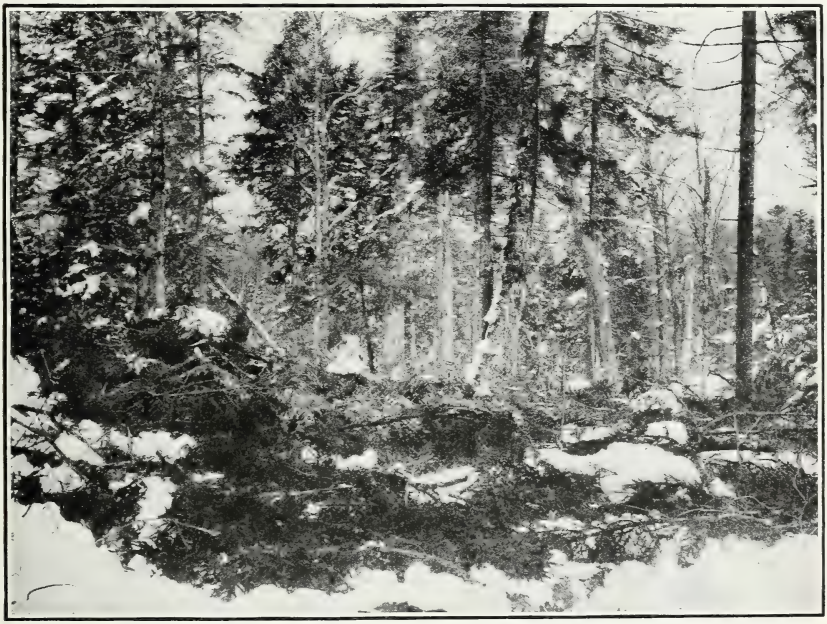

FIG. 2.—A PROPERLY LOPPED TOP. ALL PARTS BROUGHT IN CONTACT WITH THE GROUND, PROMOTING DECAY AND THUS MATERIALLY REDUCING THE FIRE HAZARD AFTER FROM 5 TO 7 YEARS.

BRUSH DISPOSAL: TOP-LOPPING.

FIG. 1.—BRUSH PROPERLY PILED READY FOR BURNING.

FIG. 2.—BRUSH WHICH WAS CUT AND PILED IN SEPTEMBER BEING BURNED IN LATE DECEMBER (18 INCHES OF SNOW).

BRUSH DISPOSAL: PILED AND BURNING.

recedes from a fire and it is impracticable to build a new one, the whole top is hauled near the fire by the skidders before being trimmed.

The advantages of the method are several. The brush is disposed of as the logging proceeds, leaving the ground free for skidding. The cost of handling is kept to a minimum, since the branch wood is handled only once and does not require to be cut up small to insure being completely destroyed, since the tops burn readily, even on the snow or in stormy weather. The time of logging in these forests, particularly those in the Northeastern States and New York, is generally the late fall or early winter when the weather is damp or snowy and the danger of the fire spreading is almost negligible. By this method a minimum of area is burned over, which is of importance when there is young growth on the ground to be protected. A too dense young growth or deep snow at the time of logging makes the method impracticable, but for the stands here considered these hindrances will seldom be encountered.

BRUSH PILED FOR BURNING.

Where cutting is done in the spring for peeled pulp wood the weather conditions may not be favorable for the use of the method just described. In this case the brush would be piled when convenient and the burning deferred until subsequent damp weather or until after the first snow of the succeeding winter. Brush piling is best carried on in conjunction with the cutting and skidding operations. It is then only necessary to employ one extra man, who cuts up and piles the branches as they are lopped from the stem. The brush is thus immediately cleared away for the skidding of the logs and a second handling avoided, which means a considerable saving in expense. Then, too, more efficient work results when the men who trim the pile work together. Supervision is also less costly when the brush piling is made a part of the logging work than when it is a separate operation.

Brush piles should be small, not over 10 feet across and 6 feet high, with the branch wood closely and systematically piled, tops of the branches toward the center of the pile, the small branches in the bottom to facilitate the firing of the pile, and the piles well isolated from one another, from down logs, lopped tops, reproduction, and the trees to be left standing. Trimmed sticks leaned against the pile hold it in shape, keep it from being blown over, and render it more compact for burning. Compactness in piling is the key to efficient, clean burning. Loosely piled brush requires repiling or constant tending when burning to insure complete destruction, both of which operations are expensive. The cost of piling and burning varies with the condition of the stand between 10 and 50 cents per thousand board feet of timber cut.

BURNING THE PILED BRUSH.

Careful organization of the work should precede the burning of piled brush. A sufficient force of men equipped with fire-fighting implements should be on hand to prevent the fire from getting beyond control. Burning should not be attempted in windy or dry weather. The most opportune time is after the first snow of winter. The piles are then dry enough to burn well, except for the outer snow-covered layer. There is little or no danger of the fire running along the ground, and the snow cover on the branches of the standing trees affords the necessary protection against their injury by the rising flames. In the absence of snow, damp weather is essential to insure the ground being wet enough to prevent the spread of the fire. With a slight wind, other things being favorable, burning may take place, provided the fires are started on the leeward side of the area and progress against the wind. Likewise when brush is being burned on a slope the uppermost piles should be started first, the progress being from the upper to the lower level of the slopes. A further precaution is necessary where the piles are close, namely, that only every other or every third pile be fired at first and these allowed to burn down before the remaining ones are started. If all the piles are fired together, a strong uninterrupted upward current of heated air will inevitably cause injury to the remaining standing trees even if they have short crowns, well up from the ground. The alternate unburned piles act as a check by interposing cool air spaces, thus isolating separate fires.

BROADCAST BURNING.

Broadcast burning has been previously mentioned in connection with the clean cutting in strips of even-aged spruce stands. Here the object is not only to get rid of the large amount of brush which cuttings of this sort yield, but to eliminate as well the deep accumulation of undecomposed litter which greatly hinders the coming in of spruce seedlings and also constitutes a menace to what seedlings do succeed in getting established by endangering their future destruction by fire. It is also cheaper than piling and burning. In using this method the logging is conducted in the ordinary way, except that the tops are lopped to allow the mass a better opportunity to settle and thus facilitate clean burning.

The same or greater care must be exercised in using this method to insure its complete control. Favorable climatic conditions must be chosen and a well-equipped force of men provided. The slash should be fired at a time when it is dry enough to burn well, but not so dry as to endanger the adjoining timber and allow the fire to get beyond control. The brush in the open area will dry out more rapidly after a drenching rain or moderate fall of snow than will the timbered

area, so that if the fire is properly timed the brush can be burned while the timbered area is still too damp to burn freely.

Isolating and subdividing burning area.—The area to be burned over must first be isolated from the contiguous uncut areas by the clearing of all inflammable matter from wide strips on all sides. This may be accomplished by throwing all tops and lops for a distance of from 20 to 40 feet from the edge in toward the center of the cleared area. It would be preferable, though, to clear away, pile, and burn all brush on such strips in the manner previously described before attempting to burn the remainder. If the cleaned area is of considerable extent, a wise precaution would be to pile and burn similar fire lines through the middle, thus dividing the area into halves or quarters. If the area is small, the logging roads will serve as intermediate fire lines.

With the necessary control lines cleared and burned, the general burning would begin at the leeward side or along the upper end if the cleared strip is on a hillside. The plots between logging roads would serve as units for burning. Only alternate plots along the leeward or uphill front should be kindled, and these should be allowed to burn down before another set is fired.

The method is unquestionably more dangerous than burning in piles, demanding a larger force to handle it. Careful judgment in the choice of time for burning is essential. The method should never be employed where the mineral soil is thin or nearly lacking as is the case on many of the steep, bowlder-strewn upper slopes in both New Hampshire and the Adirondacks. Under such circumstances the main purpose would be defeated and the slopes rendered barren and unproductive

LIGHT BURNING.

Under certain conditions the annual or periodic burning of the litter under growing stands might be advisable. Where there are dense, even-aged, planted, or natural stands in which thinnings are not to be made and therefore humus disintegrations can not be controlled, an occasional light burning would afford protection from damage by an uncontrolled ground fire during a drought. The soil would also be put in a more receptive condition for reproduction when the final cutting was made. The operation requires extreme care, otherwise its purpose will be defeated.

The recommendation for the use of this means of fire protection and soil improvement is qualified and made contingent upon the adoption of the following precautions:

The stand to be thus treated must be established on moderately deep mineral soil.

Except where the slope is very gentle, any accumulation of litter should be removed from the upslope side of the trees before burning.

The burning should not be undertaken until the trees are sufficiently large to have developed a suitable thickness of corky bark to afford the necessary protection from injury, and are sufficiently cleared of their lower branches to afford opportunity for the fire tenders to get about easily and to control the fire.

In the absence of roads or other cleared areas which might be used for fire control, ground-cleared fire lines should be provided around the border and possibly at intervals within the stand, particularly if a hillside is to be burned.

Burning should be restricted to a time, preferably early spring, when the loose top litter is dry but the under layers and soil are damp. The burning must not be allowed to reach to mineral soil.

A sufficient force of men properly equipped for fire fighting should be in attendance to check a too deep burning and prevent the fire getting beyond control.

The plan of burning in strips along a well-defined and protected front with gradual progress away from it should be followed. All other precautions mentioned elsewhere should be carefully observed.

Light burning is not advisable in selection stands where the reproduction and young growth form a distinct asset, since they would inevitably be injured or destroyed. It has a place where dense, even-aged stands are to be cut clean and reproduced by natural regeneration methods, although too much emphasis can not be laid on the danger of fire escaping and the taking of every precaution necessary to prevent it.

SOWING AND PLANTING.

It is highly probable that it will eventually be found profitable to plant many of the spruce areas when they are cut over, rather than to wait for the slower and less certain restocking by natural means. This will come first on those areas at present covered with even-aged stands and such of the selection stands as are understocked with young growth or chiefly cut for pulp wood.

A comparison of yields will suffice to show the advantages to be attained by planting over cutting under the selection system. Thus the average yield per acre of spruce in Maine at the present time, cutting to a 12-inch diameter limit, is placed by lumbermen at about 2,000 board feet. With a diameter limit of 12 inches, a period of 49 years must elapse before a similar amount can again be harvested. It is obvious that a cut to 8 inches would still yield material of a size suitable for pulp wood and would increase the present cut per acre to about 3,000 feet board measure [1] (5 cords) and reduce proportionately the cost of logging. But with an 8-inch diameter limit it is

[1] The approximate correctness of this figure is borne out by a yield table prepared for the "Lower spruce and hardwood lands" in Maine, by Hosmer, appearing in the report of the forest commissioner, Maine, 1902.

quite probable that a second cut could not again be secured short of 100 years, and it would also be increasingly difficult, if not impossible, to secure satisfactory natural restocking.

By comparison the same land managed under a system of clean cutting and planting could reasonably be expected in 60 years to yield at least 50 cords from trees 8 inches and over in diameter at breast height and an additional 10 cords from trees between 6 and 8 inches, or a total of 60 cords. A further advantage, though of minor importance, is that with the planted stand the material produced would be uniformly of a size to be easily handled by hand in the bolt. If handled in the log, the cost of logging would be somewhat more than the cost of handling larger timber.

DIRECT SEEDING.

Under certain circumstances it may be found advantageous to sow the seed broadcast in the places where the future forest is to be, simulating methods of nature. This will give satisfactory results where an abundance of seed can be secured cheaply and where an extensive area too stony or otherwise encumbered to admit of planting economically is to be reforested, but only as the result is viewed from the standpoint of the whole. Acre for acre the result will be less satisfactory than planting, particularly in commercial reforestation, for there will be many bare places, which will increase the cost in proportion to the amount of land that lies unproductive throughout the life of the resulting crop. If the bare spots are planted later, that will increase the cost. Other methods of a more or less extensive character are: Broadcasting the seed on previously plowed strips; planting with a corn planter; or hand planting in prepared seed spots. These methods are not ordinarily well adapted to red spruce; for as the intensiveness of the method increases, the cost very nearly approaches that of planting seedlings, which would be much more likely to succeed.

PLANTING.

On account of the tenderness of spruce, its exacting demands on the quality of the seedbed, and its slow growth in early youth, much more satisfactory results will be obtained in reforestation by planting than by sowing. The choice of stock is of great importance. If the ground cover is dense, the soil wet or dry or subject to freezing, or if direct insolation is strong, especially thrifty plants must be used, such as three of four year old nursery transplants. For planting on an area from which the surface cover has been recently removed and the mineral soil exposed two-year-old nursery seedlings will suffice, provided the situation is sheltered and the too prolific development of brush and weeds can be prevented. A slight nurse cover for

spruce is of advantage during the period when it is becoming established. Where each tree represents an investment, however, the nurse cover must not be allowed to interfere with the seedling's normal development.

Costs.—The following cost data for red spruce are based on the experience of the State of New York in its reforestation operations:

Average market price of spruce seed (ranging in price from $3 to $7) per pound	$4.50
Cost of collecting seed	$0.90–1.50
Cost per thousand to raise 2-year-old seedlings (based on 500,000 seedlings annually)	1.33
Three-year-old transplants	3.23
Four-year-old transplants	3.73

The cost per acre of making plantations, using various aged stock and different spacings was as follows: Using 2-year-old seedlings spaced 4 by 4 feet apart (2,722 trees per acre), $11.79; spaced 5 by 5 feet (1,742 trees per acre), $7.54; spaced 6 by 6 feet (1,210 trees per acre), $5.24; using 3-year-old transplants spaced 4 by 4 feet, $19.41; spaced 5 by 5 feet, $12.42; spaced 6 by 6 feet, $8.63; using 4-year-old transplants spaced 4 by 4 feet, $22.67; spaced 5 by 5 feet, $14.51; spaced 6 by 6 feet, $10.08. No allowance is made in the above figures on planting for the cost of transporting the seedlings from the nursery to the planting site, since it is too variable.

SOURCES OF PLANTING STOCK.

Because of the slow growth in early life of red spruce planting stock, it is difficult to handle both in nursery transplanting and in the field where 2-year seedlings are used. This unquestionably will be a strong factor in limiting the planting of this species, since both white and Norway spruce (*Picea canadensis* and *P. excelsa*) are much more satisfactory in this respect. For small operations, the purchase of planting stock will usually be cheaper than the raising of home-grown stock. Where extensive planting is to be undertaken, however, the field planting and nursery work can be coordinated to advantage and placed under the direction of an experienced manager, in which event a local nursery is desirable.[1]

The use of wild seedlings of this species, if collected as they occur in the woods without selection and transplanted directly to the permanent site, would yield very irregular and unsatisfactory results. Such stock would be of all sizes and of various ages from 1 to 10 or 15 years, with poorly developed, widely ramifying root systems and spindly tops. More uniform results would be obtained if the seedlings were set in nursery lines for a year, and a careful selection and grading made possible. The wild transplants would still be

[1] A detailed description of the subject of raising and planting coniferous seedlings will be found in Bulletin 76, Forest Service, U. S. Department of Agriculture, "How to Grow and Plant Conifers in the Northeastern States."

inferior to straight nursery-grown stock; and the expense of transplanting, tending in the nursery lines, and grading would bring their cost up to that of the more satisfactory nursery-grown seedlings.

SPACING IN PLANTING.

For general commercial planting a spacing of 5 by 6 feet or 6 by 6 feet apart is recommended. Moderately close planting is necessary with spruce to stimulate its growth in height and to provide for the closing of the crown cover and suppression of its lower branches. Such a stand properly thinned should show a final yield in 45 years of from 32 to 55 cords per acre in addition to the intermediate yields from thinnings. Wider planting, as, for instance, 8 by 8 feet or 8 by 10 feet, is advocated in some quarters to obviate the necessity of thinning under a short rotation for the production of pulpwood. The timber produced by such a method would be short, big-butted, with a quick taper, and clothed with green, or at best poorly suppressed, dead branches well down to the ground. Such a stand might be expected to yield between three-fourths and 1 cord per acre per annum with a 30 to 35 year rotation.

ROTATION.

Some consideration has already been given to the rotation in connection with the discussion of methods of cutting and of thinnings. As indicated in Table 17, a rotation of from 55 to 60 years under average, natural, even-aged conditions will yield a maximum of pulpwood volume. Judicious thinnings should reduce this rotation from 5 to 10 years, increasing the gross volume, including the volume of yield from thinnings, at the same time. For saw timber and dimension stuff a rotation of from 100 to 120 years should yield a satisfactory return under management for selection as well as even-aged forest conditions, as shown by Tables 15 and 16. In the case of selection forests, of course, the quantitative yield would be small as compared to even-aged stands, but this disadvantage should be offset to an appreciable extent by the better than average quality yield.

APPENDIX.

VOLUME TABLES.

The volume tables for spruce which follow are divided between the various units of measure and comprise 12 board-foot tables, 4 cubic-foot tables, and 3 cord tables.

Board-foot tables.—The board-foot tables are all for old-growth spruce, except one of the New Hampshire tables, which is for old-field spruce. Since a different log rule is in use in each of the four principal spruce States, the data in each State has been worked up by the Scribner Decimal C rule for purposes of comparison.

Of the four Maine tables two are based on the total height of the tree and two on the number of 16-foot logs, each according to the Scribner Decimal C and Maine log rules.

The New Hampshire tables are five, one of which, Table 29, is for second-growth spruce. The old-growth volumes are given in terms both of the New Hampshire and Scribner Decimal C rules on the basis of total height and number of 16-foot logs.

Both New York tables are according to the Scribner Decimal C rule, one of which is based on the total height of the tree and the other on the number of 16-foot logs. Although the Standard is not a board-foot measure at all, tables of volume in terms of Standards (Dimmick rule) on the basis of total height and of 16-foot logs are here included for purposes of comparison.

The West Virginia tables are divided between the Scribner Decimal C and Doyle rules, each on the basis of the total height of the tree and on the number of 16-foot logs.

Cubic-foot tables.—The cubic-foot tables (Nos. 38 to 41, inclusive) are all for old-growth spruce except No. 39 for New Hampshire, which is a combination of old-growth and "old-field" spruce. These tables being all for approximately the same utilization at stump and top, afford a good opportunity for comparison of development in the different localities. According to the tables given, the diameters and heights run about the same for Maine and New Hampshire, but the Maine trees are generally fuller bodied, as indicated by a larger cubic content for the same diameter and height. Had the New Hampshire data been from the northern instead of the southern part of the State, it would doubtless have exceeded that in Maine in height and diameter and in volume as well. This is because spruce

is generally believed to reach its New England optimum in northern New Hampshire. For equal heights and diameters Maine shows fuller-bodied boles than West Virginia, yet in general development West Virginia greatly excels.

Cordwood tables.—Old-field spruce is most commonly sold by the cord for pulp, sometimes rough and at other times peeled. Hence Tables 42, 43, and 44 were prepared for New Hampshire conditions, where old-field growth is most prevalent. Table 43, based on 5-inch utilization in the tops, was derived from Table 44 by interpolation. Table 43 was used for scaling the sample plots for Table 17.

TABLE 21.—*Board-foot volume of red spruce in Maine, according to the Scribner Decimal C rule and total height of tree.*

[CURVED.]

Diameter breast high.	Total height of tree—feet.						Basis.
	40	50	60	70	80	90	
	Volume—board feet.						
Inches.							*Trees.*
7	5	10	15	.....	.....	.....	8
8	15	20	25	.....	.....	.....	11
9	25	30	40	.....	.....	.....	18
10	35	45	55	60	.....	.....	29
11	50	60	70	80	.....	.....	21
12	60	80	90	110	.....	.....	27
13	80	100	120	130	.....	.....	20
14	90	120	140	160	170	.....	22
15	.....	140	170	190	200	.....	13
16	.....	160	200	220	240	260	11
17	.....	.....	230	250	280	310	14
18	.....	.....	260	290	330	360	19
19	.....	.....	.....	330	380	420	6
20	.....	.....	.....	380	430	480	6
21	.....	.....	.....	430	490	540	6
22	.....	.....	.....	480	550	610	4
23	.....	.....	.....	530	610	680	4
24	.....	.....	.....	.....	670	750	.....
25	.....	.....	.....	.....	730	830	2
							241

Based on taper curves, scaled as 8 and 16 foot logs. Stump height, 1 foot; diameter inside bark of top, 6 to 9 inches.

Data collected by R. S. Hosmer in Piscataquis County in 1902.

TABLE 22.—*Board-foot volume of red spruce in Maine according to the Scribner Decimal C rule and number of 16-foot logs.*

[CURVED.]

Diameter breast high.	Number of 16-foot logs.									Basis.
	1	1½	2	2½	3	3½	4	4½	5	
	Volume—board feet.									
Inches.										*Trees.*
7	10	20								8
8	15	25								11
9	20	30	35							18
10	25	40	50	60						29
11	35	50	70	80						21
12	40	60	80	100	110					27
13		70	100	120	130					20
14		90	120	140	160	170				22
15			140	170	190	200				13
16			160	190	220	240	270			11
17				220	250	280	310			14
18				250	280	320	360	400		19
19					330	370	410	450		6
20					370	410	450	500	550	6
21					410	450	500	560	620	6
22						490	560	620	690	4
23						540	610	690	770	4
24							670	760	850	
25							730	830	930	2
										241

Based on taper curves, scaled as 8 and 16 foot logs. Stump height, 1 foot; diameter inside bark of top, 6 to 9 inches.

Data collected by R. S. Hosmer in Piscataquis County in 1902.

TABLE 23.—*Board-foot volume of red spruce in Maine according to the Maine rule and total height of tree.*

[CURVED.]

Diameter breast high.	Total height of tree—feet.						Basis.
	40	50	60	70	80	90	
	Volume—board feet.						
Inches.							*Trees.*
7	15	20	25				8
8	25	35	40				11
9	40	50	60				18
10	50	70	80	90			29
11	60	80	100	110			21
12	80	100	120	130			27
13	90	120	140	160			20
14	110	140	170	190	210		22
15		170	190	220	250		13
16		190	220	250	280	310	11
17			250	290	320	360	14
18			270	320	370	410	19
19				360	410	460	6
20				400	450	520	6
21				440	500	580	6
22				480	550	630	4
23				520	600	690	4
24					650	750	
25					700	810	2
							241

Based on taper curves. Logs scaled in lengths of from 8 to 16 feet. Stump height, 1 foot; diameter inside bark of top, 6 inches.

Data collected by R. S. Hosmer in Piscataquis County in 1902.

TABLE 24.—*Board-foot volume of red spruce in Maine according to the Maine rule and number of 16-foot logs.*

[CURVED.]

Diameter breast high.	Number of 16-foot logs.								Basis.
	1	1½	2	2½	3	3½	4	4½	
	Volume—board feet.								
Inches.									*Trees.*
7	20	25	.....	.....	.....	.....	.....	.....	8
8	30	35	40	.....	.....	.....	.....	.....	11
9	35	45	50	.....	.....	.....	.....	.....	18
10	45	50	70	80	.....	.....	.....	.....	29
11	50	70	80	100	.....	.....	.....	.....	21
12	60	80	100	110	140	.....	.....	.....	27
13	.....	90	110	130	160	.....	.....	.....	20
14	.....	.....	130	150	180	220	.....	.....	22
15	.....	.....	150	170	210	240	.....	.....	13
16	.....	.....	170	200	230	270	310	.....	11
17	.....	.....	.....	220	260	300	350	.....	14
18	.....	.....	.....	250	290	340	390	440	19
19	.....	.....	.....	.....	330	370	420	480	6
20	.....	.....	.....	.....	360	410	460	520	6
21	.....	.....	.....	.....	390	450	510	570	6
22	.....	.....	.....	.....	.....	500	560	620	4
23	.....	.....	.....	.....	.....	550	610	680	4
24	.....	.....	.....	.....	.....	.....	670	740	.....
25	.....	.....	.....	.....	.....	.....	740	820	2
									241

Based on taper curves. Logs scaled in lengths of from 8 to 16 feet. Stump height, 1 foot; diameter inside bark of top, 6 inches.
Data collected by R. S. Hosmer in Piscataquis County in 1902.

TABLE 25.—*Board foot volume of red spruce in New Hampshire according to the Scribner Decimal C rule and total height of tree.*

[CURVED.]

Diameter breast high.	Total height of tree—feet.						Basis.
	30	40	50	60	70	80	
	Volume—board feet.						
Inches.							*Trees.*
8	20	24	31	40	55	.....	76
9	26	32	40	52	67	.....	75
10	32	40	49	63	80	98	87
11	36	49	59	76	95	120	76
12	40	58	72	90	110	140	87
13	.....	68	85	100	130	160	54
14	.....	78	99	120	150	180	68
15	.....	90	110	140	170	210	33
16	.....	100	130	160	200	240	36
17	.....	120	150	180	230	270	24
18	.....	130	170	210	260	310	21
19	.....	.....	190	240	290	350	13
20	.....	.....	210	270	320	390	9
21	.....	.....	240	300	360	430	3
22	.....	.....	270	330	400	470	3
23	.....	.....	.....	370	440	520	.....
24	.....	.....	.....	410	480	570	.....
25	.....	.....	.....	450	530	620	.....
26	.....	.....	.....	490	580	670	3
.....	.....	.....	.....	.....	.....	.....	668

Based on taper curves; scaled mostly as 16.3-foot logs, with a few shorter logs where necessary.
Stump height, 1 foot; diameter inside bark of top, 6 inches.
Data collected by T. S. Woolsey, jr., in Grafton County in 1903.

TABLE 26.—*Board-foot volume of red spruce in New Hampshire according to the Scribner Decimal C rule and number of 16-foot logs.*

[CURVED.]

Diameter breast high.	Number of 16-foot logs.							Basis.
	1	1½	2	2½	3	3½	4	
	Volume—board feet.							
Inches.								*Trees.*
8	20	30	43	59	.....	.....	.....	76
9	21	33	46	63	.....	.....	.....	75
10	22	37	50	69	89	.....	.....	87
11	23	42	56	76	98	.....	.....	76
12	24	48	63	85	110	140	.....	87
13	.....	56	72	95	120	150	.....	54
14	.....	65	81	110	130	170	210	68
15	.....	75	92	120	150	190	230	33
16	.....	.....	100	130	170	210	260	36
17	.....	.....	120	150	190	240	290	24
18	.....	.....	130	170	210	270	320	21
19	.....	.....	.....	190	240	300	350	13
20	.....	.....	.....	210	270	330	380	9
21	.....	.....	.....	240	300	360	420	3
22	.....	.....	.....	270	330	400	460	3
23	.....	.....	.....	.....	360	440	500	.....
24	.....	.....	.....	.....	400	480	550	.....
25	.....	.....	.....	.....	440	520	600	.....
26	.....	.....	.....	.....	480	560	650	3
								668

Based on taper curves; scaled mostly as 16.3-foot logs, with a few shorter logs where necessary.
Stump height, 1 foot; diameter inside bark of top, 6 inches.
Data collected by T. S. Woolsey, jr., in Grafton County in 1903.

TABLE 27.—*Board-foot volume of red spruce in New Hampshire according to the New Hampshire rule and total height of tree.*

[CURVED.]

Diameter breast high.	Total height of tree—feet.						Basis.
	30	40	50	60	70	80	
	Volume—board feet.						
Inches.							*Trees.*
8	26	30	36	44	51	.....	76
9	35	43	50	60	71	.....	75
10	45	56	66	78	91	100	87
11	58	70	83	97	110	120	76
12	72	85	100	120	130	150	87
13	.....	100	120	140	150	180	54
14	.....	120	140	160	180	210	68
15	.....	140	160	180	210	240	33
16	.....	160	180	210	240	270	36
17	.....	180	200	240	270	310	24
18	.....	200	230	270	300	350	21
19	.....	.....	260	300	340	390	13
20	.....	.....	290	330	380	430	9
21	.....	.....	320	360	420	470	3
22	.....	.....	350	400	460	510	3
23	.....	.....	.....	440	500	560	.....
24	.....	.....	.....	470	540	610	.....
25	.....	.....	.....	510	580	660	.....
26	.....	.....	.....	540	620	710	3
							668

Based on taper curves; scaled mostly as 16.3-foot logs, with a few shorter logs where necessary.
Stump height, 1 foot; diameter inside bark of top, 6 inches.
Data collected by T. S. Woolsey, jr., in Grafton County in 1903.

TABLE 28.—*Board-foot volume of red spruce in New Hampshire according to the New Hampshire rule and number of 16-foot logs.*

[CURVED.]

Diameter breast high.	Number of 16-foot logs.							Basis.
	1	1½	2	2½	3	3½	4	
	Volume—board feet.							
Inches.								*Trees.*
8	26	34	49	65	.....	.....	.....	76
9	35	43	57	75	.....	.....	.....	75
10	44	53	67	86	110	.....	.....	87
11	55	64	78	98	120	.....	.....	76
12	66	76	92	110	130	160	.....	87
13	.....	88	110	120	150	180	.....	54
14	.....	100	120	140	170	200	240	68
15	.....	120	140	160	190	220	270	33
16	.....	.....	160	180	210	250	300	36
17	.....	.....	180	200	240	280	330	24
18	.....	.....	200	220	270	310	360	21
19	.....	.....	.....	250	300	340	390	13
20	.....	.....	.....	280	330	370	430	9
21	.....	.....	.....	310	360	410	470	3
22	.....	.....	.....	340	390	450	510	3
23	.....	.....	.....	.....	420	490	550	.....
24	.....	.....	.....	.....	460	530	590	.....
25	.....	.....	.....	.....	500	570	630	.....
26	.....	.....	.....	.....	540	610	670	3
								668

Based on taper curves; scaled mostly as 16.3-foot logs, with a few shorter logs where necessary.
Stump height 1 foot. Diameter inside bark of top, 6 inches.
Data collected by T. S. Woolsey, jr., in Grafton County in 1903.

TABLE 29.—*Board-foot volume of old-field red spruce in New Hampshire according to the New Hampshire rule and total height of tree.*

[CURVED.]

Diameter breast high.	Total height of tree—feet.			Basis.
	40	50	60	
	Board feet.			
Inches.				*Trees.*
7	18	23	28	(1)
8	30	37	44	(1)
9	42	50	59	(1)
10	55	65	76	(1)
11	68	80	93	(1)
12	.....	96	111	(1)
13	.....	113	129	(1)
14	.....	129	148	(1)

[1] Impossible to give, old table.

Scaled "straight and sound" in tree lengths cutting to a diameter outside the bark of 6 inches. If logs are cut to a limit of 4 inches in the top, trees under 10 inches will scale about 10 per cent more; those over 10 inches about 1 per cent more.
Based on the measurement of 579 trees made by T. S. Woolsey, jr., in 1903.

TABLE 30.—*Board-foot volume of red spruce in New York according to the Scribner Decimal C rule and total height of tree.*

[CURVED.]

Diameter breast high.	Total height of tree—feet.								Basis.
	30	40	50	60	70	80	90	100	
	Volume—board feet.								
Inches.									*Trees.*
8	18	26	34	41	48	.....	.....	.....	87
9	26	35	43	53	67	75	.....	.....	63
10	35	45	55	67	78	90	100	.....	158
11	45	56	68	82	96	110	130	140	178
12	55	67	82	97	110	130	150	170	214
13	.....	78	97	120	130	160	180	200	136
14	.....	90	110	130	160	180	200	230	189
15	.....	100	120	150	180	210	230	260	112
16	.....	.....	140	170	200	240	270	300	93
17	.....	.....	160	190	230	270	300	340	79
18	.....	.....	180	220	260	300	340	380	77
19	.....	.....	.....	250	290	340	380	430	39
20	.....	.....	.....	270	320	380	430	480	44
21	.....	.....	.....	300	360	420	480	540	17
22	.....	.....	.....	320	400	470	540	600	16
23	.....	.....	.....	.....	440	530	600	670	6
24	.....	.....	.....	.....	490	580	670	750	6
25	.....	.....	.....	.....	540	640	740	840	1
26	.....	.....	.....	.....	600	710	820	930	1
									1,507

Diameter inside bark of top, 6 inches; stump height, 1 foot. Based on taper curves; scaled mostly as 16.3-foot logs, with a few shorter logs where necessary.

Based in part on measurements taken under the direction of the Superintendent of State Forests, New York, in Essex and Herkimer Counties, 1912.

TABLE 31.—*Board-foot volume of red spruce in New York according to the Scribner Decimal C rule and number of 16-foot logs.*

[CURVED.]

Diameter breast high.	Number of 16-foot logs.									Basis.
	1	1½	2	2½	3	3½	4	4½	5	
	Volume—board feet.									
Inches.										*Trees.*
8	19	32	43	56	.....	.....	.....	.....	.....	87
9	24	36	49	64	73	.....	.....	.....	.....	63
10	30	41	56	72	85	100	.....	.....	.....	158
11	36	47	65	81	98	120	.....	.....	.....	178
12	42	54	74	91	110	130	160	.....	.....	214
13	.....	60	84	100	130	150	180	.....	.....	136
14	.....	67	95	120	140	170	200	230	.....	180
15	.....	75	110	130	160	190	220	260	.....	112
16	.....	.....	120	150	180	210	250	290	.....	93
17	.....	.....	130	160	200	230	270	320	.....	79
18	.....	.....	140	180	220	260	300	350	410	77
19	.....	.....	.....	200	240	290	340	390	450	39
20	.....	.....	.....	210	260	320	370	430	500	44
21	.....	.....	.....	.....	290	350	410	470	550	17
22	.....	.....	.....	.....	320	380	450	520	600	16
23	.....	.....	.....	.....	350	410	490	570	660	6
24	.....	.....	.....	.....	380	450	530	620	730	6
25	.....	.....	.....	.....	410	480	580	680	800	1
26	.....	.....	.....	.....	450	520	630	750	870	1
										1,507

Based on taper curves; scaled mostly as 16.3-foot logs, with a few shorter logs where necessary. Diameter inside bark of top, 6 inches; stump height, 1 foot.

Based in part on measurements taken under the direction of the Superintendent of State Forests, New York, in Essex and Herkimer Counties, 1912.

TABLE 32.—*Standard volume of red spruce in New York according to the Dimick rule and total height of tree.*

[CURVED.]

Diameter breast high.	Total height of tree—feet.								Basis.
	30	40	50	60	70	80	90	100	
	Volume—standards.[1]								
Inches.									*Trees.*
8	0.14	0.19	0.24	0.29	0.32	.....	.....	.....	87
9	.18	.24	.30	.36	.41	.....	.....	.....	63
10	.22	.29	.37	.44	.50	0.56	.....	.....	158
11	.....	.34	.44	.54	.62	.70	.....	.....	178
12	.....	.39	.52	.64	.74	.83	0.92	.....	214
13	.....	.45	.60	.74	.86	.97	1.07	.....	136
14	.....	.52	.69	.84	.99	1.12	1.24	1.36	180
15	.....	.....	.77	.94	1.12	1.28	1.42	1.55	112
16	.....	.....	.86	1.06	1.26	1.44	1.61	1.76	93
17	.....	.....	.95	1.18	1.40	1.62	1.81	1.99	79
18	.....	.....	1.05	1.31	1.57	1.80	2.03	2.23	77
19	.....	.....	.....	1.43	1.73	2.00	2.26	2.49	39
20	.....	.....	.....	1.55	1.90	2.22	2.51	2.78	44
21	.....	.....	.....	1.69	2.08	2.44	2.77	3.08	17
22	.....	.....	.....	1.83	2.27	2.67	3.04	3.39	16
23	.....	.....	.....	.....	2.47	2.90	3.32	3.72	6
24	.....	.....	.....	.....	2.66	3.14	3.61	4.06	6
25	.....	.....	.....	.....	2.85	3.39	3.92	4.42	1
26	.....	.....	.....	.....	3.04	3.64	4.23	4.80	1
									1,507

[1] A Dimick standard is equal to the volume of a log 19 inches in diameter inside bark at the small end and 13 feet long. A cylinder of these dimensions contains 25.6 cubic feet.

Diameter inside bark of top, 6 inches; stump height, 1 foot. Based on taper curves; scaled mostly as 16.3-foot logs, with a few shorter logs where necessary.

Based in part on measurements taken under the direction of the Superintendent of State Forests, New York, in Essex and Herkimer Counties, 1912.

TABLE 33.—*Standard volume of red spruce in New York according to the Dimick rule and number of 16-foot logs.*

[CURVED.]

Diameter breast high.	Number of 16-foot logs.									Basis.
	1	1½	2	2½	3	3½	4	4½	5	
	Volume—standards.[1]									
Inches.										*Trees.*
8	0.14	0.22	0.29	0.37	.....	.....	.....	.....	.....	87
9	.16	.24	.33	.42	0.47	.....	.....	.....	.....	63
10	.19	.28	.38	.47	.55	0.66	.....	.....	.....	158
11	.22	.32	.43	.53	.63	.75	.....	.....	.....	178
12	.26	.36	.48	.60	.72	.85	0.98	.....	.....	214
13	.....	.41	.53	.66	.80	.95	1.10	.....	.....	136
14	.....	.46	.59	.73	.89	1.06	1.23	1.41	.....	180
15	.....	.51	.65	.81	.98	1.17	1.36	1.56	.....	112
16	.....	.....	.71	.89	1.08	1.29	1.50	1.71	.....	93
17	.....	.....	.77	.97	1.18	1.41	1.64	1.88	.....	79
18	.....	.....	.83	1.05	1.29	1.54	1.80	2.07	2.39	77
19	.....	.....	.....	1.14	1.40	1.68	1.96	2.17	2.59	39
20	.....	.....	.....	1.22	1.51	1.82	2.14	2.48	2.81	44
21	.....	.....	.....	.....	1.64	1.98	2.33	2.69	3.05	17
22	.....	.....	.....	.....	1.77	2.14	2.53	2.92	3.31	16
23	.....	.....	.....	.....	1.92	2.32	2.74	3.16	3.60	6
24	.....	.....	.....	.....	2.07	2.51	2.96	3.41	3.90	6
25	.....	.....	.....	.....	2.22	2.70	3.19	3.68	4.20	1
26	.....	.....	.....	.....	2.38	2.89	3.44	3.96	4.51	1
										1,507

[1] A Dimick standard is equal to the volume of a log 19 inches in diameter inside bark at the small end and 13 feet long. A cylinder of these dimensions contains 25.6 cubic feet.

Based on taper curves, scaled mostly as 16.3-foot logs, with a few shorter logs where necessary.

Diameter inside bark of top, 6 inches; stump height, 1 foot.

Based in part on measurements taken under the direction of the Superintendent of State Forests, New York, in Essex and Herkimer Counties, 1912.

TABLE 34.—*Board-foot volume of red spruce in West Virginia according to the Doyle rule and total height of tree.*

[CURVED.]

Diameter breast high.	Height of tree—feet.							Basis.
	50	60	70	80	90	100	110	
	Volume—board feet.							
Inches.								*Trees.*
8	5	10						2
9	15	20						10
10	25	30	30	35				19
11	35	40	45	50				40
12	45	50	60	70	80			33
13		70	80	90	100			42
14		80	100	120	130	140		38
15		100	130	150	160	180		29
16		120	150	180	200	220	240	31
17			180	210	240	260	290	23
18			210	250	280	310	350	24
19				280	330	370	410	16
20				330	380	430	470	22
21				380	440	490	540	18
22				420	500	560	610	18
23					560	630	690	15
24					620	700	770	6
25					690	780	860	8
26					760	860	960	4
27						940	1,070	5
28						1,040	1,170	6
29						1,140	1,290	3
30						1,240	1,400	1
31						1,340	1,530	2
32						1,440	1,660	
33						1,540	1,800	1
34						1,650	1,940	
								416

Based on taper curves. Logs scaled in lengths from 8 to 17 feet. Stump height, 1 foot; diameter inside bark of top, 6 inches.

Data collected by John Foley in Greenbrier County in 1903.

TABLE 35.—*Board-foot volume of red spruce in West Virginia according to the Doyle rule and number of 16-foot logs.*

[CURVED.]

Diameter breast high.	Number of 16-foot logs.										Basis.
	1½	2	2½	3	3½	4	4½	5	5½	6	
	Volume—board feet.										
Inches.											*Trees.*
8	5	10									2
9	10	15									10
10	15	25	30	30							19
11		35	40	45							40
12		45	50	60	70	80					33
13			70	80	90	100					42
14			80	100	110	130	150				38
15			100	120	140	150	180				29
16				140	160	180	210	240			31
17				160	190	220	250	280			23
18					220	250	280	320	360		24
19					250	290	330	370	410		16
20					290	330	370	420	480		22
21					330	370	420	480	540		18
22					360	410	470	540	610		18
23						460	530	600	680		15
24						510	590	670	760		6
25							660	750	830	920	8
26							740	820	910	1,010	4
27								910	1,000	1,100	5
28								1,000	1,090	1,190	6
29								1,090	1,190	1,300	3
30								1,180	1,290	1,410	1
31									1,400	1,520	2
32									1,520	1,640	
33									1,630	1,750	1
34									1,750	1,870	
											416

Based on taper curves. Logs scaled in lengths from 8 to 17 feet. Stump height, 1 foot; diameter inside bark of top, 6 inches.

Data collected by John Foley in Greenbrier County in 1903.

TABLE 36.—*Board-foot volume of red spruce in West Virginia according to Scribner Decimal C rule and total height of tree.*

[CURVED.]

Diameter breast high.	Height of tree—feet.							Basis.
	50	60	70	80	90	100	110	
	Volume—board feet.							
Inches.								*Trees.*
8	20	25	.....	.....	.....	.....	.....	2
9	30	35	.....	.....	.....	.....	.....	10
10	45	50	60	70	.....	.....	.....	19
11	60	70	80	90	.....	.....	.....	40
12	75	90	110	120	140	.....	.....	33
13	.....	120	140	150	170	.....	.....	42
14	.....	150	170	190	210	230	.....	38
15	.....	180	200	220	250	280	.....	29
16	.....	210	230	260	300	330	350	31
17	.....	.....	260	300	340	380	410	23
18	.....	.....	300	340	390	440	480	24
19	.....	.....	.....	390	450	500	540	16
20	.....	.....	.....	440	500	560	610	22
21	.....	.....	.....	480	570	630	690	18
22	.....	.....	.....	540	630	710	770	18
23	.....	.....	.....	.....	700	780	860	15
24	.....	.....	.....	.....	770	860	960	6
25	.....	.....	.....	.....	840	940	1,050	8
26	.....	.....	.....	.....	910	1,030	1,150	4
27	.....	.....	.....	.....	.....	1,130	1,270	5
28	.....	.....	.....	.....	.....	1,230	1,390	6
29	.....	.....	.....	.....	.....	1,340	1,520	3
30	.....	.....	.....	.....	.....	1,450	1,660	1
31	.....	.....	.....	.....	.....	1,570	1,790	2
32	.....	.....	.....	.....	.....	1,680	1,930	.....
33	.....	.....	.....	.....	.....	1,790	2,060	1
34	.....	.....	.....	.....	.....	1,910	2,200	.....
								416

Based on taper curves scaled as 8 and 16 foot logs. Stump height, 1 foot; diameter inside bark of top, 6 to 9 inches.

Data collected by John Foley in Greenbrier County in 1903.

TABLE 37.—*Board-foot volume of red spruce in West Virginia according to Scribner Decimal C rule and number of 16-foot logs.*

[CURVED.]

Diameter breast high.	Number of 16-foot logs.									Basis.
	1½	2	2½	3	3½	4	4½	5	5½	6	
	Volume—board feet.										
Inches.											*Trees.*
8	25	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
9	25	40	.....	.....	.....	.....	.....	.....	.....	.....	10
10	30	50	70	80	.....	.....	.....	.....	.....	.....	19
11	.....	60	80	100	.....	.....	.....	.....	.....	.....	40
12	.....	80	100	120	140	.....	.....	.....	.....	.....	33
13	.....	.....	120	140	160	180	.....	.....	.....	.....	42
14	.....	.....	140	170	190	220	240	.....	.....	.....	38
15	.....	.....	160	190	220	250	280	.....	.....	.....	29
16	.....	.....	190	220	250	280	320	350	.....	.....	31
17	.....	.....	.....	250	280	320	360	400	.....	.....	23
18	.....	.....	.....	280	310	360	400	450	.....	.....	24
19	.....	.....	.....	.....	350	400	450	510	550	.....	16
20	.....	.....	.....	.....	380	440	510	570	630	.....	22
21	.....	.....	.....	.....	420	490	560	640	710	.....	18
22	.....	.....	.....	.....	.....	530	620	710	790	.....	18
23	.....	.....	.....	.....	.....	.....	700	780	880	.....	15
24	.....	.....	.....	.....	.....	.....	770	860	970	.....	6
25	.....	.....	.....	.....	.....	.....	840	940	1,070	1,210	8
26	.....	.....	.....	.....	.....	.....	910	1,030	1,160	1,310	4
27	.....	.....	.....	.....	.....	.....	.....	1,120	1,250	1,410	5
28	.....	.....	.....	.....	.....	.....	.....	1,210	1,340	1,510	6
29	.....	.....	.....	.....	.....	.....	.....	1,290	1,440	1,620	3
30	.....	.....	.....	.....	.....	.....	.....	1,380	1,540	1,730	1
31	.....	.....	.....	.....	.....	.....	.....	.....	1,620	1,840	2
32	.....	.....	.....	.....	.....	.....	.....	.....	1,710	1,950	.....
33	.....	.....	.....	.....	.....	.....	.....	.....	1,810	2,060	1
34	.....	.....	.....	.....	.....	.....	.....	.....	1,910	2,180	.....
											416

Based on taper curves, scaled as 8 and 16 foot logs. Stump height, 1 foot; diameter inside bark of top, 6 to 9 inches.
Data collected by John Foley in Greenbrier County in 1903.

TABLE 38.—*Cubic-foot volume of red spruce in Maine.*

[CURVED.]

Diameter breast high.	Height of tree—feet.						Basis.
	40	50	60	70	80	90	
	Merchantable volume, including bark—cubic feet.						
Inches.							*Trees.*
6	3.0	4.5	5.0	.....	.....	.....	5
7	5.0	6.5	7.5	.....	.....	.....	8
8	7.0	9.0	10.5	.....	.....	.....	11
9	9.5	11.5	13.5	.....	.....	.....	18
10	12.0	14.5	17.0	18.5	.....	.....	29
11	14.5	17.5	20.5	22.5	.....	.....	21
12	17.5	21.0	24.5	27.0	.....	.....	27
13	21.0	25.0	28.5	31.5	.....	.....	20
14	.....	29.0	33.5	36.5	40.0	.....	22
15	.....	33.5	38.5	42.0	46.0	.....	13
16	.....	38.5	43.5	48.0	52.5	57.5	11
17	.....	.....	49.0	54.0	59.5	65.5	14
18	.....	.....	54.5	60.5	67.0	73.5	19
19	.....	.....	.....	67.0	74.5	82.0	6
20	.....	.....	.....	74.0	82.5	91.0	6
21	.....	.....	.....	81.5	91.5	101.0	6
22	.....	.....	.....	89.5	100.0	111.0	4
23	.....	.....	.....	97.5	109.0	122.0	4
24	.....	.....	.....	.....	118.5	133.0	.....
25	.....	.....	.....	.....	127.5	144.5	2
							246

Based on taper curves. Stump height, 1 foot; diameter outside bark of top, 4.5 inches.
Data collected by R. S. Hosmer in Piscataquis County in 1902.

TABLE 39.—*Cubic-foot volume of red spruce, virgin and second growth,*[1] *in southern New Hampshire.*

MERCHANTABLE VOLUME—(UNPEELED).

[CURVED.]

Diameter breast high.	Height of tree—feet.						Basis.	
	40	50	60	70	80	90	All trees.	Second-growth trees only.
	Volume—cubic feet.							
Inches.								
5	1.9	2.5	3.0	.....	.....	.....	29	29
6	3.5	4.2	5.2	6.4	.....	.....	98	98
7	5.0	6.2	7.5	9.0	.....	.....	128	127
8	6.6	8.4	10.0	11.7	.....	.....	165	163
9	8.5	10.8	12.7	14.8	.....	.....	161	155
10	.....	13.5	15.6	18.0	.....	.....	113	103
11	.....	16.5	18.8	21.5	.....	.....	78	64
12	.....	19.5	22.3	25.4	.....	.....	63	37
13	.....	.....	26.0	29.5	34.5	.....	42	22
14	.....	.....	30.0	34.0	39.5	.....	55	29
15	.....	.....	34.5	38.5	44.0	.....	56	23
16	.....	.....	39.0	43.5	49.0	.....	49	18
17	.....	.....	43.5	49.0	55.0	63.5	38	10
18	.....	.....	48.0	54.5	61.0	70.0	44	9
19	.....	.....	53.0	60.5	67.5	77.0	30	6
20	.....	.....	58.0	67.0	74.5	83.5	21	.....
21	.....	.....	.....	74.0	82.0	90.5	18	.....
22	.....	.....	.....	81.5	89.0	98.0	16	.....
23	.....	.....	.....	88.5	96.5	105.0	10	.....
24	.....	.....	.....	95.5	104.5	114.0	5	.....
25	.....	.....	.....	102.0	112.0	123.0	2	.....
26	.....	.....	.....	109.0	120.0	131.5	2	.....
27	.....	.....	.....	.....	128.0	140.0	2	.....
28	.....	.....	.....	.....	135.5	148.5	1	.....
							1,226	893

[1] Values within the black lines are a combination of old-growth and second-growth measurements which worked up separately gave practically identical results.

NOTE.—Stumps varying from ½ foot to 1½ feet high and tops above 4 inches outside bark excluded from volume.

Bark=11 per cent of volume given.

Data collected by Louis Margolin in 1906.

TABLE 40.—*Cubic-foot volume of red spruce in New York.*

[CURVED.]

Diameter breast high.	Total height of tree—feet.								Basis.
	30	40	50	60	70	80	90	100	
	Merchantable volume, including bark—cubic feet.								
Inches.									*Trees.*
6	3.6	4.5	5.4	6.3	.....	.....	.....	.....	44
7	4.8	6.0	7.2	8.4	.....	.....	.....	.....	40
8	6.2	7.8	9.3	10.9	12.4	.....	.....	.....	87
9	7.7	9.7	11.6	13.5	15.5	.....	.....	.....	63
10	9.5	12.0	14.3	16.8	19.2	21.5	.....	.....	158
11	.....	14.4	17.2	20.0	23.0	26.0	.....	.....	178
12	.....	17.1	20.5	24.0	27.5	31.0	34.5	.....	214
13	.....	19.9	23.5	27.5	32.0	36.0	40.0	.....	136
14	.....	23.0	27.5	32.0	37.0	41.5	46.0	51	180
15	.....	.....	31.5	37.0	42.0	47.5	53.0	58	112
16	.....	.....	35.5	41.5	48.0	54.0	60.0	66	93
17	.....	.....	40.0	47.0	54.0	61.0	68.0	74	79
18	.....	.....	44.5	52.0	60.0	68.0	76.0	83	77
19	.....	.....	.....	58.0	67.0	75.0	84.0	92	39
20	.....	.....	.....	64.0	74.0	83.0	93.0	102	44
21	.....	.....	.....	71.0	81.0	92.0	102.0	113	17
22	.....	.....	.....	77.0	89.0	101.0	112.0	123	16
23	.....	.....	.....	.....	97.0	110.0	123.0	135	6
24	.....	.....	.....	.....	106.0	119.0	133.0	146	6
25	.....	.....	.....	.....	114.0	130.0	145.0	159	1
26	.....	.....	.....	.....	124.0	140.0	156.0	172	1
									1,591

Stump height, 1 foot; top diameter outside bark, 4.5 inches. Based on taper curves.
Based in part on measurements taken under the direction of the Superintendent of State Forests, New York, in Essex and Herkimer Counties, 1912.

TABLE 41.—*Cubic-foot volume of red spruce in West Virginia.*

[CURVED.]

Diameter breast high.	Height of tree—feet.							Basis.
	50	60	70	80	90	100	110	
	Merchantable volume, including bark—cubic feet.							
Inches.								*Trees.*
6	3.5	.....	.....	.....	.....	.....	.....	.....
7	6.0	.....	.....	.....	.....	.....	.....	1
8	8.5	10.0	.....	.....	.....	.....	.....	2
9	11.0	13.0	.....	.....	.....	.....	.....	10
10	14.0	16.0	18.5	20.5	.....	.....	.....	19
11	17.0	19.5	22.5	24.5	.....	.....	.....	40
12	20.0	23.5	26.5	29.5	32.5	.....	.....	33
13	.....	27.5	31.0	34.5	38.0	.....	.....	42
14	.....	32.0	36.0	40.0	44.5	48.0	.....	38
15	.....	36.5	41.5	45.5	51.0	56.0	.....	29
16	.....	41.5	47.0	52.0	58.5	64.0	69.5	31
17	.....	.....	52.5	58.5	66.0	72.5	78.5	23
18	.....	.....	58.0	66.0	74.0	81.0	88.0	24
19	.....	.....	.....	73.0	82.0	90.0	98.0	16
20	.....	.....	.....	81.0	91.0	100.0	108.5	22
21	.....	.....	.....	88.5	100.0	110.5	120.0	18
22	.....	.....	.....	97.0	110.0	121.5	132.0	18
23	.....	.....	.....	.....	120.0	132.5	144.5	15
24	.....	.....	.....	.....	130.5	144.0	157.5	6
25	.....	.....	.....	.....	141.0	156.5	171.0	8
26	.....	.....	.....	.....	152.0	169.0	185.5	4
27	.....	.....	.....	.....	.....	182.0	200.5	5
28	.....	.....	.....	.....	.....	195.0	216.0	6
29	.....	.....	.....	.....	.....	209.0	232.0	3
30	.....	.....	.....	.....	.....	223.0	249.0	1
31	.....	.....	.....	.....	.....	237.5	265.5	2
32	.....	.....	.....	.....	.....	252.5	283.0	.....
33	.....	.....	.....	.....	.....	268.5	302.0	1
34	.....	.....	.....	.....	.....	284.5	321.0	.....
								417

Based on taper curves. Stump height, 1 foot: diameter outside bark of top, 4.5 inches.
Data collected by John Foley in Greenbrier County in 1903.

TABLE 42.—*Cordwood volume of red spruce (old-field) in New Hampshire, bark included.*

[CURVED.]

Diameter breast high.	Height of tree—feet.				
	40	50	60	70	80
	Volume—cords.[1]				
Inches.					
6	0.028	0.032	0.041	.....	.....
7	.048	.058	.070	.....	.....
8	.070	.084	.099	.....	.....
9	.093	.110	.129	0.155	.....
10	.115	.137	.160	.185	.....
11	.....	.164	.199	.217	.....
12	.....	.192	.220	.250	.....
13	.....	.....	.252	.282	0.314
14	.....	.....	.284	.315	.349
15	.....	.....	.316	.348	.384
16	.....	.....	.348	.381	.419
17	.....	.....	.380	.414	.455
18	.....	.....	.411	.447	.490

[1] Includes bark.

Top diameter outside bark, 5 inches. Based on 711 trees, measured by T. S. Woolsey, jr., in Grafton County in 1911.
One cord of stacked wood equals 96 cubic feet of solid wood and bark.

TABLE 43.—*Cordwood volume of red spruce (old-field) in New Hampshire, bark included.*

Diameter breast high.	Trees 40 feet high.				Trees 50 feet high.			
	Volume cutting to—		Trees per cord, cutting to—		Volume cutting to—		Trees per cord, cutting to—	
	6 inches.	4 inches.	6 inches.	4 inches.	6 inches.	4 inches.	6 inches.	4 inches.
Inches.	*Cord.*	*Cord.*			*Cord.*	*Cord.*		
6	.....	0.039	.....	25.6	.....	0.045	.....	22.2
7	0.033	.060	30.3	16.6	0.043	.069	23.2	14.5
8	.....	.....	.....	.....	.071	.093	14.1	10.7
9	.....	.....	.....	.....	.100	.120	10.0	8.3
10	.....	.....	.....	.....	.129	.144	7.7	6.9
11	.....	.....	.....	.....	.159	.170	6.2	5.8
	Trees 60 feet high.				Trees 70 feet high.			
6	.....	0.052	.....	19.2	.....	.....	.....	.....
7	0.051	.083	19.6	12.0	.....	.....	.....	.....
8	.088	.112	11.3	8.9	.....	.....	.....	.....
9	.120	.139	8.3	7.2	0.150	0.162	6.6	6.1
10	.150	.168	6.6	5.9	.180	.193	5.5	5.2
11	.179	.199	5.6	5.0	.211	.220	4.7	4.5
12	.212	.230	4.7	4.3	.243	.256	4.1	3.9
13	.245	.263	4.1	3.8	.266	.289	3.7	3.5
14	.279	.294	3.5	3.4	.310	.322	3.2	3.1

Basis, 711 trees measured by T. S. Woolsey, jr., in Grafton County in 1903.
One cord of stacked wood equals 96 cubic feet of solid wood and bark.

TABLE 44.—*Cordwood volume of red spruce (old-field) in New Hampshire, bark excluded.*

Diameter breast high.	Trees 40 feet high.				Trees 50 feet high.			
	Volume cutting to—		Trees per cord, cutting to—		Volume cutting to—		Trees per cord, cutting to—	
	6 inches.	4 inches.	6 inches.	4 inches.	6 inches.	4 inches.	6 inches.	4 inches.
Inches.	*Cord.*	*Cord.*			*Cord.*	*Cord.*		
6	.....	0.032	.....	31.2	.....	0.040	.....	25.0
7	0.028	.051	35.7	19.6	0.038	.061	26.3	16.4
8	.....	.....	.....	.....	.065	.081	15.4	12.3
9	.....	.....	.....	.....	.088	.102	11.3	9.8
10	.....	.....	.....	.....	.113	.125	8.8	8.0
11	.....	.....	.....	.....	.137	.150	7.3	6.6
	Trees 60 feet high.				Trees 70 feet high.			
6	.....	0.047	.....	21.3	.....	.....	.....	.....
7	0.046	.074	21.7	13.5	.....	.....	.....	.....
8	.077	.100	12.9	10.0	.....	.....	.....	.....
9	.108	.123	9.2	8.1	0.133	0.142	7.5	7.0
10	.136	.146	7.2	6.8	.162	.171	6.2	5.8
11	.161	.173	6.2	5.7	.190	.199	5.2	5.0
12	.186	.199	5.3	5.0	.218	.229	4.5	4.3
13	.213	.226	4.7	4.4	.247	.258	4.0	3.8
14	.243	.255	4.1	3.5	.277	.289	3.6	3.4

Basis, 711 trees measured by T. S. Woolsey, jr., in Grafton County in 1903.
One cord of stacked wood equals 96 cubic feet of solid wood and bark.

TAPER MEASUREMENTS.

Changing economic conditions, due to invention, increasing demand, and decreasing supply, cause corresponding changes in logging practice and mill utilization. It is essential that we have some means readily available by which volume and other tables may be revised or new ones made as these changes take place. Taper tables afford such a means by showing for each 10-foot height class and each 1-inch diameter class (breastheight diameter measured outside the bark), the diameter inside the bark at 1-foot intervals from the ground up to 4.5 feet (breastheight), and at 8.15-foot intervals above a 1-foot stump height. The allowance of 0.15 of a foot at each 8-foot section is for loss in trimming at the mill. The taper tables (Tables 45 to 49) for each of the four States are all for "old-growth" spruce, except Table 46, which is for "second-growth" or "old-field" spruce.

TABLE 45.—*Taper measurements (diameter inside bark) of red spruce in Maine.*

40-FOOT TREES.

[CURVED.]

Diameter breast high.	Height above ground—feet.													Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	58.05	66.2	74.35	
	Diameter inside bark—inches.													
Inches.														*Trees.*
6	7.6	7.0	6.2	5.5	4.9	4.3	3.4							4
7	8.8	8.1	7.3	6.4	5.9	5.2	4.1							5
8	9.9	9.2	8.4	7.4	6.8	6.0	4.7							3
9	11.0	10.2	9.5	8.4	7.8	6.9	5.5							6
10	12.2	11.3	10.6	9.3	8.6	7.7	6.2							5
11	13.3	12.4	11.6	10.3	9.5	8.5	6.9							5
12	14.4	13.5	12.7	11.3	10.4	9.4	7.6							
13	15.6	14.6	13.7	12.2	11.4	10.3	8.3							2
14	16.7	15.6	14.7	13.2	12.4	11.2	9.1							1
														31

50-FOOT TREES.

6	7.6	7.0	6.2	5.5	5.2	4.7	4.2	3.3						
7	8.8	8.1	7.3	6.4	6.0	5.5	4.9	3.9						2
8	9.9	9.2	8.4	7.4	6.9	6.3	5.7	4.5						8
9	11.0	10.2	9.5	8.4	7.8	7.1	6.4	5.1						7
10	12.2	11.3	10.6	9.3	8.7	8.0	7.1	5.7						10
11	13.3	12.4	11.6	10.3	9.6	8.8	7.9	6.3						7
12	14.4	13.5	12.7	11.3	10.5	9.6	8.6	6.9						7
13	15.6	14.6	13.7	12.2	11.5	10.5	9.4	7.6						5
14	16.7	15.6	14.7	13.2	12.4	11.1	10.2	8.2						1
15	17.9	16.7	15.8	14.1	13.3	12.1	11.0	8.8						
16	19.0	17.8	16.8	15.1	14.2	12.8	11.7	9.4						1
														48

60-FOOT TREES.

6	7.6	7.0	6.2	5.5	5.0	4.7	4.4	3.9	3.0	1.8				1
7	8.8	8.1	7.3	6.4	6.0	5.6	5.2	4.6	3.5	2.1				1
8	9.9	9.2	8.4	7.4	7.0	6.5	5.9	5.1	4.1	2.5				
9	11.0	10.2	9.5	8.4	7.9	7.3	6.7	5.9	4.7	2.8				5
10	12.2	11.3	10.6	9.3	8.8	8.1	7.5	6.6	5.2	3.1				9
11	13.3	12.4	11.6	10.3	9.8	9.0	8.2	7.2	5.7	3.5				7
12	14.4	13.5	12.7	11.3	10.7	9.8	9.0	8.0	6.2	3.7				9
13	15.6	14.6	13.7	12.2	11.6	10.6	9.8	8.6	6.8	4.1				11
14	16.7	15.6	14.7	13.2	12.5	11.4	10.5	9.3	7.3	4.4				11
15	17.9	16.7	15.8	14.1	13.4	12.2	11.3	10.0	7.8	4.7				8
16	19.0	17.8	16.8	15.1	14.3	13.0	12.1	10.6	8.2	5.0				1
17	20.3	19.0	17.8	16.0	15.1	13.8	12.8	11.3	8.8	5.3				1
18	21.5	20.2	18.9	17.0	16.1	14.6	13.5	12.0	9.3	5.5				
														64

70-FOOT TREES.

10	12.2	11.3	10.6	9.3	8.8	8.1	7.7	7.1	6.0	4.4	2.6			5
11	13.3	12.4	11.6	10.3	9.7	8.9	8.4	7.7	6.6	4.9	2.9			2
12	14.4	13.5	12.7	11.3	10.7	9.8	9.1	8.4	7.2	5.5	3.2			11
13	15.6	14.6	13.7	12.2	11.5	10.6	9.9	9.0	7.8	5.9	3.5			2
14	16.7	15.6	14.7	13.2	12.5	11.5	10.6	9.6	8.3	6.4	3.8			6
15	17.9	16.7	15.8	14.1	13.4	12.3	11.4	10.4	9.0	6.8	4.2			3
16	19.0	17.8	16.8	15.1	14.3	13.1	12.1	11.1	9.5	7.3	4.5			5
17	20.3	19.0	17.8	16.0	15.3	14.0	12.9	11.8	10.1	7.8	4.8			8
18	21.5	20.2	18.9	17.0	16.2	14.8	13.6	12.4	10.6	8.2	5.0			7
19	22.8	21.3	20.0	18.0	17.1	15.6	14.3	13.0	11.2	8.7	5.4			
20	24.1	22.5	21.1	18.9	18.0	16.4	15.0	13.7	11.8	9.1	5.6			1
21	25.3	23.6	22.2	19.9	18.8	17.2	15.9	14.3	12.3	9.6	6.0			3
22	26.6	24.8	23.3	20.9	19.8	18.0	16.6	15.0	12.9	10.0	6.3			1
23	27.9	26.0	24.4	21.9	20.7	18.9	17.3	15.6	13.4	10.5	6.6			1
														55

TABLE 45.—*Taper measurements (diameter inside bark) of red spruce in Maine*—Contd.

80-FOOT TREES.

[CURVED.]

Diameter breast high.	Height above ground—feet.													Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	58.05	66.2	74.35	
	Diameter inside bark—inches.													
Inches.														*Trees.*
14	16.7	15.6	14.7	13.2	12.4	11.4	10.6	9.8	8.8	7.4	5.6	3.6	.....	3
15	17.9	16.7	15.8	14.1	13.4	12.3	11.5	10.6	9.5	7.9	6.1	3.9	.....	2
16	19.0	17.8	16.8	15.1	14.3	13.1	12.2	11.2	10.1	8.5	6.6	4.2	.....	4
17	20.3	19.0	17.8	16.0	15.1	14.0	13.1	12.1	10.8	9.1	7.0	4.5	.....	5
18	21.5	20.2	18.9	17.0	16.1	14.8	13.8	12.8	11.5	9.7	7.5	4.8	.....	11
19	22.8	21.3	20.0	18.0	17.2	15.8	14.6	13.5	12.2	10.4	8.0	5.1	.....	2
20	24.1	22.5	21.1	18.9	18.0	16.6	15.4	14.2	12.9	11.0	8.4	5.4	.....	2
21	25.3	23.6	22.2	19.9	18.9	17.5	16.2	15.0	13.5	11.5	8.9	5.8	.....	3
22	26.6	24.8	23.3	20.9	19.9	18.3	17.0	15.7	14.1	12.0	9.3	6.1	.....	2
23	27.9	26.0	24.4	21.9	20.8	19.1	17.8	16.4	14.8	12.6	9.7	6.4	.....	3
24	29.3	27.2	25.5	22.8	21.7	19.9	18.4	17.0	15.4	13.1	10.2	6.7	.....	.....
25	30.6	28.5	26.6	23.8	22.6	20.7	19.2	17.7	16.0	13.7	10.6	6.9	.....	1
														38
	90-FOOT TREES.													
16	19.0	17.8	16.8	15.1	14.2	13.1	12.1	11.4	10.6	9.5	8.0	6.2	4.1	.....
17	20.3	19.0	17.8	16.0	15.1	14.0	13.0	12.3	11.4	10.2	8.6	6.5	4.3	.....
18	21.5	20.2	18.9	17.0	16.1	14.9	13.9	13.0	12.1	10.8	9.0	7.0	4.6	1
19	22.8	21.3	20.0	18.0	17.1	15.8	14.7	13.8	12.7	11.4	9.6	7.4	4.9	4
20	24.1	22.5	21.1	18.9	18.1	16.8	15.6	14.6	13.4	12.0	10.1	7.8	5.1	3
21	25.3	23.6	22.2	19.9	19.0	17.7	16.5	15.4	14.2	12.7	10.6	8.2	5.4	.....
22	26.6	24.8	23.3	20.9	20.0	18.7	17.3	16.1	14.9	13.2	11.1	8.6	5.7	1
23	27.9	26.0	24.4	21.9	21.0	19.5	18.2	17.0	15.6	13.9	11.8	9.1	6.0	.....
24	29.3	27.2	25.5	22.8	22.0	20.5	19.0	17.7	16.3	14.5	12.3	9.4	6.2	.....
25	30.6	28.5	26.6	23.8	22.9	21.4	19.8	18.5	17.1	15.2	12.9	9.9	6.5	1
														10

Data collected by R. S. Hosmer in Piscataquis County in 1902.

TABLE 46.—*Taper measurements (diameter inside bark) of red spruce (old-field) in New Hampshire.*

40-FOOT TREES. [CURVED.]

Diameter breast high.	Height above ground—feet.										Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	
	Diameter inside bark—inches.										
Inches.											*Trees.*
5	5.6	5.3	5.0	4.7	4.2	3.6	2.9	.....	.....	.....	4
6	6.7	6.3	6.0	5.6	5.1	4.4	3.5	.....	.....	.....	9
7	7.8	7.4	7.0	6.6	6.0	5.2	4.1	.....	.....	.....	8
8	9.0	8.4	8.0	7.5	6.9	6.0	4.7	.....	.....	.....	2
9	10.1	9.5	9.1	8.4	7.7	6.7	5.3	.....	.....	.....	.....
10	11.3	10.6	10.1	9.4	8.6	7.6	5.9	.....	.....	.....	2
11	12.4	11.7	11.1	10.4	9.5	8.3	6.5	.....	.....	.....	.....
12	13.6	12.8	12.2	11.4	10.4	9.0	7.0	.....	.....	.....	1
											26

50-FOOT TREES.

5	5.6	5.3	5.0	4.7	4.5	4.0	3.5	2.6	.....	.....	2
6	6.7	6.3	6.0	5.6	5.4	4.9	4.2	3.1	.....	.....	15
7	7.8	7.4	7.0	6.6	6.2	5.6	4.8	3.6	.....	.....	23
8	9.0	8.4	8.0	7.5	7.1	6.4	5.5	4.1	.....	.....	9
9	10.1	9.5	9.1	8.4	7.9	7.2	6.2	4.6	.....	.....	15
10	11.3	10.6	10.1	9.4	8.8	8.0	6.9	5.1	.....	.....	5
11	12.4	11.7	11.1	10.4	9.6	8.7	7.5	5.6	.....	.....	.....
12	13.6	12.8	12.2	11.4	10.5	9.4	8.2	6.0	.....	.....	2
											71

60-FOOT TREES.

7	7.8	7.4	7.0	6.6	6.2	5.6	5.1	4.3	3.2	.....	2
8	9.0	8.4	8.0	7.5	7.1	6.5	5.8	4.9	3.7	.....	5
9	10.1	9.5	9.1	8.4	8.0	7.4	6.6	5.6	4.2	.....	3
10	11.3	10.6	10.1	9.4	8.9	8.2	7.4	6.2	4.7	.....	2
11	12.4	11.7	11.1	10.4	9.8	9.0	8.1	6.8	5.2	.....	3
12	13.6	12.8	12.2	11.4	10.7	9.8	8.8	7.5	5.7	.....	3
13	14.8	13.9	13.2	12.4	11.6	10.6	9.6	8.1	6.1	.....	1
14	16.0	15.0	14.3	13.4	12.5	11.4	10.3	8.7	6.6	.....	1
15	17.3	16.2	15.4	14.4	13.4	12.2	11.0	9.3	7.1	.....	.....
16	18.6	17.3	16.5	15.4	14.2	13.0	11.7	10.0	7.6	.....	1
											21

70-FOOT TREES.

8	9.0	8.4	8.0	7.5	7.1	6.6	6.1	5.4	4.4	3.1	.....
9	10.1	9.5	9.1	8.4	8.0	7.5	6.9	6.0	4.9	3.5	.....
10	11.3	10.6	10.1	9.4	9.0	8.4	7.7	6.8	5.5	3.9	.....
11	12.4	11.7	11.1	10.4	9.9	9.2	8.5	7.4	6.0	4.3	.....
12	13.6	12.8	12.2	11.4	10.8	10.0	9.2	8.0	6.6	4.7	1
13	14.8	13.9	13.2	12.4	11.8	10.9	9.9	8.7	7.1	5.1	.....
14	16.0	15.0	14.3	13.4	12.7	11.7	10.7	9.4	7.6	5.5	.....
15	17.3	16.2	15.4	14.4	13.7	12.6	11.5	10.0	8.1	5.8	1
16	18.6	17.3	16.5	15.4	14.6	13.5	12.3	10.7	8.7	6.2	.....
17	19.8	18.5	17.6	16.4	15.5	14.3	13.0	11.4	9.2	6.5	.....
18	21.1	19.6	18.8	17.4	16.4	15.1	13.8	12.1	9.8	6.9	1
											3

Data collected by T. S. Woolsey, jr., in Grafton County in 1903.

TABLE 47.—*Taper measurements (diameter inside bark) of red spruce (old-growth) in New Hampshire.*

30-FOOT TREES. [CURVED.]

Diameter breast high.	Height above ground—feet.												Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	58.05	66.2	
	Diameter inside bark—inches.												
Inches.													*Trees.*
6	6.5	6.0	5.7	5.5	4.8	4.4	2.5						3
7	7.7	7.1	6.7	6.5	5.7	5.0	2.8						2
8	8.8	8.2	7.8	7.5	6.6	5.7	3.2						2
9	9.9	9.3	8.8	8.4	7.5	6.4	3.5						
10	11.1	10.4	9.9	9.4	8.4	7.1	3.9						
11	12.3	11.5	11.0	10.4	9.3	7.8	4.2						
12	13.4	12.6	12.1	11.4	10.3	8.5	4.6						
													7

40-FOOT TREES.

6	6.5	6.0	5.7	5.5	5.2	4.7	3.7	2.0					14
7	7.7	7.1	6.7	6.5	6.1	5.4	4.4	2.4					23
8	8.8	8.2	7.8	7.5	6.9	6.1	5.1	2.8					39
9	9.9	9.3	8.8	8.4	7.7	6.8	5.7	3.2					24
10	11.1	10.4	9.9	9.4	8.6	7.6	6.4	3.7					16
11	12.3	11.5	11.0	10.4	9.4	8.3	7.0	4.1					2
12	13.4	12.6	12.1	11.4	10.3	9.0	7.7	4.6					2
13	14.6	13.7	13.1	12.4	11.1	9.7	8.3	5.0					
14	15.7	14.8	14.2	13.3	12.0	10.5	9.0	5.4					1
15	16.9	15.9	15.3	14.3	12.8	11.2	9.6	5.9					
16	18.0	17.0	16.3	15.3	13.6	12.0	10.3	6.3					
17	19.1	18.1	17.3	16.3	14.5	12.7	11.0	6.8					1
18	20.3	19.1	18.4	17.2	15.3	13.4	11.6	7.2					
													122

50-FOOT TREES.

6	6.5	6.0	5.7	5.5	5.4	4.9	4.6	4.1	2.8				3
7	7.7	7.1	6.7	6.5	6.2	5.6	5.1	4.5	3.1				10
8	8.8	8.2	7.8	7.5	7.1	6.4	5.8	5.0	3.4				29
9	9.9	9.3	8.8	8.4	7.9	7.2	6.4	5.5	3.6				34
10	11.1	10.4	9.9	9.4	8.8	8.0	7.1	6.0	3.9				41
11	12.3	11.5	11.0	10.4	9.6	8.7	7.8	6.4	4.1				29
12	13.4	12.6	12.1	11.4	10.5	9.4	8.4	6.9	4.4				14
13	14.6	13.7	13.1	12.4	11.3	10.1	9.1	7.4	4.6				13
14	15.7	14.8	14.2	13.3	12.2	10.9	9.7	7.8	4.8				6
15	16.9	15.9	15.3	14.3	13.0	11.7	10.4	8.3	5.0				1
16	18.0	17.0	16.3	15.3	13.9	12.4	11.0	8.8	5.2				2
17	19.1	18.1	17.3	16.3	14.7	13.2	11.7	9.3	5.5				1
18	20.3	19.1	18.4	17.2	15.5	13.9	12.3	9.8	5.7				
19	21.3	20.2	19.4	18.2	16.3	14.6	13.0	10.3	6.0				
20	22.4	21.3	20.4	19.2	17.1	15.3	13.6	10.8	6.2				
21	23.5	22.4	21.4	20.1	18.0	16.0	14.3	11.2	6.4				1
22	24.6	23.4	22.4	21.1	18.8	16.8	14.9	11.7	6.7				
													184

TABLE 47.—*Taper measurements (diamter inside bark) of red spruce (old-growth) in New Hampshire.*

60-FOOT TREES.

Diameter breast high.	Height above ground—feet.											Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	58.05	66.2	
	Diameter inside bark—inches.												
Inches.													*Trees.*
6	6.5	6.0	5.7	5.5	5.4	5.1	4.9	4.5	3.8	2.6	.....	.....	1
7	7.7	7.1	6.7	6.5	6.2	5.9	5.5	5.0	4.2	2.9	.....	.....	1
8	8.8	8.2	7.8	7.5	7.1	6.6	6.2	5.6	4.6	3.2	.....	.....	6
9	9.9	9.3	8.8	8.4	8.0	7.4	6.8	6.1	5.1	3.5	.....	.....	16
10	11.1	10.4	9.9	9.4	8.9	8.2	7.5	6.7	5.5	3.8	.....	.....	29
11	12.3	11.5	11.0	10.4	9.8	8.9	8.2	7.3	5.9	4.1	.....	.....	41
12	13.4	12.6	12.1	11.4	10.7	9.7	8.9	7.9	6.4	4.4	.....	.....	47
13	14.6	13.7	13.1	12.4	11.5	10.5	9.6	8.4	6.8	4.6	.....	.....	27
14	15.7	14.8	14.2	13.4	12.4	11.2	10.3	9.0	7.3	4.9	.....	.....	37
15	16.9	15.9	15.3	14.3	13.2	12.0	10.9	9.6	7.7	5.2	.....	.....	15
16	18.0	17.0	16.3	15.3	14.0	12.7	11.6	10.2	8.2	5.5	.....	.....	17
17	19.1	18.1	17.3	16.3	14.8	13.5	12.3	10.8	8.7	5.8	.....	.....	9
18	20.3	19.1	18.4	17.2	15.7	14.3	13.0	11.4	9.2	6.1	.....	.....	4
19	21.3	20.2	19.4	18.2	16.5	15.0	13.7	11.9	9.6	6.4	.....	.....	1
20	22.4	21.3	20.4	19.2	17.4	15.8	14.4	12.5	10.0	6.7	.....	.....	4
21	23.5	22.4	21.4	20.1	18.2	16.5	15.0	13.0	10.4	6.9	.....	.....	.....
22	24.6	23.4	22.4	21.1	19.1	17.2	15.7	13.6	10.8	7.2	.....	.....	.....
23	25.7	24.4	23.3	22.1	19.8	18.0	16.3	14.1	11.2	7.4	.....	.....	.....
24	26.8	25.5	24.3	23.1	20.6	18.7	17.0	14.6	11.6	7.7	.....	.....	.....
25	27.8	26.5	25.3	24.0	21.5	19.4	17.6	15.1	12.0	7.9	.....	.....	.....
26	28.9	27.5	26.2	25.0	22.3	20.1	18.3	15.7	12.4	8.2	.....	.....	1
													256

70-FOOT TREES.

8	8.8	8.2	7.8	7.5	7.2	6.8	6.4	5.9	5.1	4.1	2.9	.....	.....
9	9.9	9.3	8.8	8.4	8.1	7.5	7.1	6.5	5.6	4.5	3.2	.....	1
10	11.1	10.4	9.9	9.4	9.0	8.3	7.8	7.1	6.1	4.9	3.4	.....	1
11	12.3	11.5	11.0	10.4	9.8	9.1	8.5	7.7	6.7	5.3	3.6	.....	4
12	13.4	12.6	12.1	11.4	10.7	9.8	9.2	8.4	7.3	5.8	3.9	.....	23
13	14.6	13.7	13.1	12.4	11.5	10.6	9.9	9.0	7.8	6.2	4.2	.....	13
14	15.7	14.8	14.2	13.3	12.4	11.4	10.6	9.7	8.4	6.6	4.4	.....	22
15	16.9	15.9	15.3	14.3	13.2	12.2	11.3	10.3	8.9	7.0	4.7	.....	15
16	18.0	17.0	16.3	15.3	14.1	13.0	12.1	11.0	9.5	7.5	4.9	.....	15
17	19.1	18.1	17.3	16.3	15.0	13.8	12.8	11.6	10.1	7.9	5.1	.....	8
18	20.3	19.1	18.4	17.2	15.9	14.5	13.6	12.3	10.7	8.4	5.4	.....	9
19	21.3	20.2	19.4	18.2	16.7	15.3	14.3	12.9	11.2	8.8	5.6	.....	8
20	22.4	21.3	20.4	19.2	17.6	16.0	15.0	13.5	11.7	9.2	5.9	.....	3
21	23.5	22.4	21.4	20.1	18.4	16.8	15.7	14.1	12.3	9.6	6.1	.....	.....
22	24.6	23.4	22.4	21.1	19.3	17.6	16.4	14.8	12.8	10.0	6.4	.....	1
23	25.7	24.4	23.3	22.1	20.2	18.4	17.1	15.4	13.4	10.5	6.7	.....	.....
24	26.8	25.5	24.3	23.1	21.0	19.1	17.8	16.0	13.9	10.9	7.0	.....	.....
25	27.8	26.5	25.3	24.0	21.9	19.9	18.4	16.7	14.5	11.3	7.3	.....	.....
26	28.9	27.5	26.2	25.0	22.7	20.5	19.1	17.3	15.0	11.7	7.6	.....	.....
													123

80-FOOT TREES.

10	11.1	10.4	9.9	9.4	9.0	8.4	7.8	7.2	6.4	5.4	4.4	2.9	.....
11	12.3	11.5	11.0	10.4	9.8	9.1	8.5	7.9	7.0	5.9	4.8	3.2	.....
12	13.4	12.6	12.1	11.4	10.7	9.9	9.3	8.6	7.6	6.4	5.2	3.5	1
13	14.6	13.7	13.1	12.4	11.6	10.7	10.0	9.3	8.3	7.0	5.6	3.8	1
14	15.7	14.8	14.2	13.3	12.5	11.5	10.8	10.0	8.9	7.6	6.0	4.1	2
15	16.9	15.9	15.3	14.3	13.3	12.3	11.5	10.7	9.5	8.1	6.4	4.3	2
16	18.0	17.0	16.3	15.3	14.2	13.1	12.3	11.4	10.2	8.6	6.8	4.6	2
17	19.1	18.1	17.3	16.3	15.1	13.9	13.0	12.1	10.8	9.1	7.2	4.9	5
18	20.3	19.1	18.4	17.2	16.0	14.7	13.8	12.8	11.5	9.6	7.6	5.2	8
19	21.3	20.2	19.4	18.2	16.9	15.5	14.6	13.5	12.1	10.1	8.0	5.4	4
20	22.4	21.3	20.4	19.2	17.8	16.3	15.3	14.2	12.7	10.6	8.4	5.6	2
21	23.5	22.4	21.4	20.1	18.6	17.1	16.1	14.9	13.3	11.1	8.7	5.8	2
22	24.6	23.4	22.4	21.1	19.5	17.9	16.8	15.6	13.9	11.7	9.1	6.1	2
23	25.7	24.4	23.3	22.1	20.3	18.7	17.6	16.3	14.5	12.3	9.5	6.4	.....
24	26.8	25.5	24.3	23.1	21.2	19.5	18.4	16.9	15.1	12.8	9.9	6.6	.....
25	27.8	26.5	25.3	24.0	22.1	20.3	19.1	17.6	15.7	13.3	10.3	6.8	.....
26	28.9	27.5	26.2	25.0	23.0	21.2	19.9	18.3	16.3	13.9	10.7	7.0	2
													33

Data collected by T. S. Woolsey, jr., in Grafton County in 1903.

TABLE 48.—*Taper measurements (diameter inside bark) of red spruce in New York.*

30-FOOT TREES. [CURVED.]

Diameter breast high.	Height above ground—feet.														Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	58.05	66.2	74.35	82.5	
	Diameter inside bark—inches.														
Inches.															*Trees.*
6...	7.6	7.0	6.3	5.6	5.4	4.4	.....	.....	.....	.....	.....	.....	.....	.....	3
7...	8.6	7.9	7.3	6.6	6.3	5.2	.....	.....	.....	.....	.....	.....	.....	.....	1
8...	9.6	8.8	8.2	7.5	7.2	6.0	.....	.....	.....	.....	.....	.....	.....	.....	1
9...	10.7	9.8	9.2	8.4	8.1	6.8	.....	.....	.....	.....	.....	.....	.....	.....	.....
10...	11.7	10.8	10.2	9.4	9.0	7.5	.....	.....	.....	.....	.....	.....	.....	.....	.....
															5

40-FOOT TREES.

6...	7.6	7.0	6.3	5.6	5.4	4.8	3.8	.....	.....	.....	.....	.....	.....	.....	35
7...	8.6	7.9	7.3	6.6	6.3	5.6	4.5	.....	.....	.....	.....	.....	.....	.....	26
8...	9.6	8.8	8.2	7.5	7.2	6.3	5.1	.....	.....	.....	.....	.....	.....	.....	27
9...	10.7	9.8	9.2	8.4	8.1	7.1	5.8	.....	.....	.....	.....	.....	.....	.....	7
10...	11.7	10.8	10.2	9.4	9.0	7.9	6.4	.....	.....	.....	.....	.....	.....	.....	9
11...	12.8	11.9	11.2	10.3	9.8	8.6	7.0	.....	.....	.....	.....	.....	.....	.....	2
12...	13.9	13.0	12.3	11.3	10.6	9.4	7.6	.....	.....	.....	.....	.....	.....	.....	.....
13...	15.1	14.1	13.3	12.2	11.5	10.1	8.2	.....	.....	.....	.....	.....	.....	.....	.....
14...	16.2	15.2	14.4	13.2	12.4	10.9	8.8	.....	.....	.....	.....	.....	.....	.....	.....
															106

50-FOOT TREES.

6...	7.6	7.0	6.3	5.6	5.4	5.1	4.5	3.5	2.0	.....	.....	.....	.....	.....	6
7...	8.6	7.9	7.3	6.6	6.3	5.8	5.2	4.1	2.3	.....	.....	.....	.....	.....	13
8...	9.6	8.8	8.2	7.5	7.2	6.6	5.8	4.6	2.6	.....	.....	.....	.....	.....	49
9...	10.7	9.8	9.2	8.4	8.1	7.4	6.5	5.1	3.0	.....	.....	.....	.....	.....	46
10...	11.7	10.8	10.2	9.4	8.9	8.2	7.1	5.6	3.2	.....	.....	.....	.....	.....	81
11...	12.8	11.9	11.2	10.3	9.8	8.9	7.8	6.2	3.6	.....	.....	.....	.....	.....	43
12...	13.9	13.0	12.3	11.3	10.6	9.6	8.5	6.6	3.9	.....	.....	.....	.....	.....	35
13...	15.1	14.1	13.3	12.2	11.5	10.4	9.1	7.1	4.2	.....	.....	.....	.....	.....	10
14...	16.2	15.2	14.4	13.2	12.3	11.1	9.6	7.6	4.5	.....	.....	.....	.....	.....	8
15...	17.4	16.4	15.5	14.2	13.1	11.8	10.3	8.1	4.8	.....	.....	.....	.....	.....	3
16...	18.7	17.5	16.6	15.1	13.9	12.5	10.9	8.6	5.2	.....	.....	.....	.....	.....	.....
17...	20.0	18.7	17.6	16.0	14.8	13.2	11.5	9.1	5.5	.....	.....	.....	.....	.....	.....
18...	21.3	19.8	18.7	17.0	15.6	13.9	12.1	9.6	5.8	.....	.....	.....	.....	.....	.....
															294

60-FOOT TREES.

6...	7.6	7.0	6.3	5.6	5.5	5.2	4.7	4.1	3.1	1.8	.....	.....	.....	.....	.....
7...	8.6	7.9	7.3	6.6	6.4	6.0	5.5	4.8	3.7	2.1	.....	.....	.....	.....	.....
8...	9.6	8.8	8.2	7.5	7.2	6.8	6.2	5.4	4.2	2.5	.....	.....	.....	.....	10
9...	10.7	9.8	9.2	8.4	8.1	7.6	7.0	6.0	4.7	2.9	.....	.....	.....	.....	10
10...	11.7	10.8	10.2	9.4	8.9	8.4	7.6	6.6	5.2	3.2	.....	.....	.....	.....	55
11...	12.8	11.9	11.2	10.3	9.8	9.1	8.3	7.2	5.7	3.6	.....	.....	.....	.....	99
12...	13.9	13.0	12.3	11.3	10.6	9.9	9.0	7.8	6.2	3.9	.....	.....	.....	.....	97
13...	15.1	14.1	13.3	12.2	11.5	10.6	9.7	8.4	6.7	4.3	.....	.....	.....	.....	44
14...	16.2	15.2	14.4	13.2	12.3	11.4	10.3	9.0	7.1	4.7	.....	.....	.....	.....	56
15...	17.4	16.4	15.5	14.2	13.1	12.1	11.0	9.6	7.7	5.1	.....	.....	.....	.....	22
16...	18.7	17.5	16.6	15.1	13.9	12.7	11.6	10.1	8.1	5.4	.....	.....	.....	.....	14
17...	20.0	18.7	17.6	16.0	14.7	13.4	12.3	10.7	8.7	5.8	.....	.....	.....	.....	7
18...	21.3	19.8	18.7	17.0	15.4	14.1	12.9	11.3	9.1	6.2	.....	.....	.....	.....	4
19...	22.7	21.0	19.8	18.0	16.3	14.8	13.6	11.9	9.6	6.6	.....	.....	.....	.....	1
20...	24.1	22.3	20.9	18.9	17.0	15.5	14.2	12.5	10.2	7.0	.....	.....	.....	.....	1
21...	25.5	23.5	22.0	19.8	17.8	16.1	14.8	13.0	10.7	7.4	.....	.....	.....	.....	.....
22...	26.9	24.8	23.1	20.8	18.5	16.8	15.3	13.5	11.2	7.8	.....	.....	.....	.....	.....
															420

TABLE 48.—*Taper measurements (diameter inside bark) of red spruce in New York*—Contd.

70-FOOT TREES.

Diameter breast high.	Height above ground—Feet.														Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	58.05	66.2			
	Diameter inside bark—Inches.														
Inches.															*Trees.*
8...	9.6	8.8	8.2	7.5	7.3	6.9	6.5	5.9	5.1	4.1	2.7	.....	.....	.....	.....
9...	10.7	9.8	9.2	8.4	8.1	7.7	7.2	6.6	5.6	4.5	3.0	.....	.....	.....	.....
10...	11.7	10.8	10.2	9.4	9.0	8.5	8.0	7.2	6.2	5.0	3.3	.....	.....	.....	13
11...	12.8	11.9	11.2	10.3	9.8	9.2	8.6	7.9	6.8	5.5	3.6	.....	.....	.....	32
12...	13.9	13.0	12.3	11.3	10.7	10.0	9.4	8.5	7.4	5.9	3.9	.....	.....	.....	66
13...	15.1	14.1	13.3	12.2	11.5	10.7	10.1	9.2	7.9	6.4	4.2	.....	.....	.....	66
14...	16.2	15.2	14.4	13.2	12.3	11.5	10.8	9.8	8.5	6.8	4.6	.....	.....	.....	81
15...	17.4	16.4	15.5	14.2	13.2	12.2	11.5	10.4	9.1	7.3	4.9	.....	.....	.....	44
16...	18.7	17.5	16.6	15.1	13.9	13.0	12.2	11.1	9.6	7.8	5.2	.....	.....	.....	35
17...	20.0	18.7	17.6	16.0	14.8	13.7	12.9	11.7	10.2	8.3	5.6	.....	.....	.....	22
18...	21.3	19.8	18.7	17.0	15.5	14.5	13.6	12.4	10.8	8.7	5.8	.....	.....	.....	12
19...	22.7	21.0	19.8	18.0	16.3	15.2	14.3	13.1	11.4	9.2	6.2	.....	.....	.....	8
20...	24.1	22.3	20.9	18.9	17.0	16.0	15.0	13.7	11.9	9.7	6.6	.....	.....	.....	4
21...	25.5	23.5	22.0	19.8	17.8	16.7	15.7	14.3	12.4	10.1	7.0	.....	.....	.....	1
22...	26.9	24.8	23.1	20.8	18.5	17.4	16.4	15.0	13.0	10.6	7.3	.....	.....	.....	.....
23...	28.4	26.0	24.2	21.7	19.3	18.1	17.1	15.6	13.6	11.1	7.6	.....	.....	.....	.....
24...	29.8	27.3	25.4	22.7	20.0	18.9	17.7	16.3	14.2	11.5	7.9	.....	.....	.....	.....
25...	31.2	28.6	26.6	23.6	20.8	19.6	18.5	17.0	14.8	12.0	8.3	.....	.....	.....	.....
26...	32.7	29.9	27.8	24.6	21.5	20.3	19.2	17.6	15.3	12.4	8.6	.....	.....	.....	.....
															384

80-FOOT TREES.

10...	11.7	10.8	10.2	9.4	9.0	8.6	8.0	7.4	6.7	5.8	4.7	3.3	.....	.....	.....
11...	12.8	11.9	11.2	10.3	9.8	9.3	8.8	8.1	7.3	6.3	5.1	3.6	.....	.....	2
12...	13.9	13.0	12.3	11.3	10.7	10.1	9.5	8.8	7.9	6.9	5.6	3.9	.....	.....	16
13...	15.1	14.1	13.3	12.2	11.5	10.8	10.3	9.6	8.6	7.4	6.0	4.2	.....	.....	15
14...	16.2	15.2	14.4	13.2	12.3	11.6	11.0	10.3	9.2	8.0	6.5	4.5	.....	.....	32
15...	17.4	16.4	15.5	14.2	13.2	12.3	11.8	11.0	9.8	8.5	6.9	4.8	.....	.....	42
16...	18.7	17.5	16.6	15.1	13.9	13.2	12.5	11.7	10.5	9.1	7.3	5.2	.....	.....	41
17...	20.0	18.7	17.6	16.0	14.7	13.9	13.3	12.4	11.1	9.6	7.8	5.4	.....	.....	38
18...	21.3	19.8	18.7	17.0	15.5	14.7	13.9	13.1	11.8	10.2	8.2	5.7	.....	.....	43
19...	22.7	21.0	19.8	18.0	16.3	15.4	14.8	13.8	12.4	10.7	8.6	6.0	.....	.....	14
20...	24.1	22.3	20.9	18.9	17.1	16.2	15.4	14.5	13.1	11.3	9.1	6.3	.....	.....	29
21...	25.5	23.5	22.0	19.8	17.9	17.0	16.2	15.2	13.7	11.8	9.5	6.7	.....	.....	11
22...	26.9	24.8	23.1	20.8	18.7	17.8	16.9	15.9	14.4	12.4	10.0	7.0	.....	.....	3
23...	28.4	26.0	24.2	21.7	19.4	18.5	17.7	16.6	15.1	13.0	10.5	7.3	.....	.....	3
24...	29.8	27.3	25.4	22.7	20.3	19.3	18.4	17.2	15.7	13.6	10.9	7.6	.....	.....	4
25...	31.2	28.6	26.6	23.6	21.1	20.1	19.1	17.9	16.4	14.2	11.4	7.9	.....	.....	.....
26...	32.7	29.9	27.8	24.6	21.9	20.9	19.9	18.7	17.0	14.7	11.8	8.2	.....	.....	.....
															293

TABLE 48.—*Taper measurements (diameter inside bark) of red spruce in New York*—Contd.

90-FOOT TREES.

Diameter breast high.	Height above ground—Feet.														Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	58.05	66.2	74.35	82.5	
	Diameter inside bark—Inches.														
Inches.															*Trees.*
12...	13.9	13.0	12.3	11.3	10.7	10.1	9.6	9.0	8.2	7.3	6.2	4.9	3.4	.....	.....
13...	15.1	14.1	13.3	12.2	11.5	10.9	10.4	9.8	8.9	7.9	6.8	5.4	3.7	.....	1
14...	16.2	15.2	14.4	13.2	12.3	11.7	11.2	10.5	9.6	8.5	7.3	5.8	4.1	.....	3
15...	17.4	16.4	15.5	14.2	13.2	12.5	12.0	11.3	10.3	9.2	7.9	6.3	4.4	.....	1
16...	18.7	17.5	16.6	15.1	14.0	13.3	12.7	12.0	10.9	9.8	8.5	6.8	4.8	.....	3
17...	20.0	18.7	17.6	16.0	14.8	14.1	13.6	12.7	11.6	10.4	9.0	7.2	5.1	.....	11
18...	21.3	19.8	18.7	17.0	15.6	14.9	14.3	13.5	12.4	11.1	9.6	7.7	5.4	.....	16
19...	22.7	21.0	19.8	18.0	16.5	15.7	15.1	14.2	13.1	11.7	10.1	8.1	5.7	.....	15
20...	24.1	22.3	20.9	18.9	17.2	16.5	15.8	14.9	13.7	12.3	10.6	8.5	6.0	.....	8
21...	25.5	23.5	22.0	19.8	18.0	17.3	16.6	15.6	14.4	12.9	11.2	9.0	6.4	.....	5
22...	26.9	24.8	23.1	20.8	18.8	18.2	17.3	16.3	15.1	13.6	11.7	9.4	6.7	.....	13
23...	28.4	26.0	24.2	21.7	19.7	18.9	18.1	17.1	15.9	14.2	12.3	9.9	7.0	.....	2
24...	29.8	27.3	25.4	22.7	20.5	19.8	18.9	17.8	16.5	14.8	12.8	10.4	7.4	.....	1
25...	31.2	28.6	26.6	23.6	21.4	20.5	19.7	18.6	17.2	15.5	13.4	10.8	7.7	.....	.....
26...	32.7	29.9	27.8	24.6	22.2	21.4	20.4	19.3	18.0	16.1	13.9	11.3	8.0	.....	.....
															79

100-FOOT TREES.

14...	16.2	15.2	14.4	13.2	12.3	11.8	11.3	10.7	9.8	8.7	7.6	6.3	4.8	3.3	.....
15...	17.4	16.4	15.5	14.2	13.1	12.6	12.1	11.4	10.4	9.4	8.2	6.9	5.3	3.7	.....
16...	18.7	17.5	16.6	15.1	13.9	13.4	12.8	12.2	11.2	10.1	8.8	7.4	5.8	4.1	.....
17...	20.0	18.7	17.6	16.0	14.7	14.2	13.6	12.8	11.9	10.8	9.5	8.0	6.3	4.4	1
18...	21.3	19.8	18.7	17.0	15.5	15.0	14.3	13.6	12.7	11.5	10.3	8.6	6.8	4.7	2
19...	22.7	21.0	19.8	18.0	16.4	15.8	15.1	14.4	13.4	12.2	10.9	9.2	7.3	5.1	1
20...	24.1	22.3	20.9	18.9	17.2	16.6	15.9	15.1	14.1	12.9	11.5	9.8	7.8	5.6	2
21...	25.5	23.5	22.0	19.8	18.1	17.4	16.7	15.9	14.8	13.6	12.2	10.4	8.3	5.9	.....
22...	26.9	24.8	23.1	20.8	19.0	18.3	17.5	16.7	15.6	14.3	12.8	10.9	8.8	6.3	.....
23...	28.4	26.0	24.2	21.7	19.9	19.1	18.3	17.4	16.3	15.0	13.5	11.6	9.3	6.7	1
24...	29.8	27.3	25.4	22.7	20.8	20.0	19.1	18.2	17.1	15.8	14.2	12.2	9.8	7.1	1
25...	31.2	28.6	26.6	23.6	21.7	20.8	19.9	18.9	17.8	16.4	14.9	12.9	10.4	7.5	1
26...	32.7	29.9	27.8	24.6	22.6	21.6	20.7	19.7	18.5	17.2	15.6	13.4	10.8	7.9	1
															10

Data collected in part under the supervision of the Superintendent of State Forests in Essex and Herkimer Counties in 1912.

TABLE 49.—*Taper measurements (diameter inside bark) of red spruce in West Virginia.*

50-FOOT TREES.

[CURVED.]

Diameter breast high.	Height above ground—Feet.															Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	58.05	66.2	74.35	82.5	90.95	98.8	
	Diameter inside bark—Inches.																
Inches.																	*Trees.*
6	7.1	6.6	6.2	5.7	5.3	4.8	4.3	3.6									
7	8.1	7.5	7.1	6.7	6.2	5.6	5.0	4.1									1
8	9.2	8.5	8.1	7.7	7.1	6.4	5.7	4.7									2
9	10.2	9.5	9.1	8.6	8.0	7.2	6.3	5.3									7
10	11.2	10.5	10.1	9.6	8.9	8.0	7.0	5.8									1
11	12.2	11.5	11.1	10.5	9.9	8.9	7.7	6.4									2
12	13.3	12.6	12.1	11.5	10.8	9.6	8.4	7.0									
																	13

60-FOOT TREES.

8	9.2	8.5	8.1	7.7	7.2	6.6	5.9	5.2	4.2	2.8							
9	10.2	9.5	9.1	8.6	8.1	7.4	6.7	5.9	4.7	3.1							3
10	11.2	10.5	10.1	9.6	9.1	8.2	7.4	6.6	5.3	3.4							10
11	12.2	11.5	11.1	10.5	9.9	9.0	8.1	7.2	5.9	3.8							13
12	13.3	12.6	12.1	11.5	10.8	9.8	8.9	7.9	6.4	4.1							6
13	14.4	13.6	13.1	12.5	11.7	10.6	9.7	8.6	7.0	4.5							4
14	15.5	14.6	14.1	13.4	12.6	11.4	10.3	9.2	7.6	4.9							
15	16.6	15.7	15.1	14.4	13.5	12.2	11.1	9.9	8.1	5.2							
16	17.7	16.8	16.2	15.4	14.4	13.0	11.8	10.5	8.6	5.5							1
																	37

70-FOOT TREES.

10	11.2	10.5	10.1	9.6	9.0	8.3	7.7	6.9	6.1	5.0	3.5						5
11	12.2	11.5	11.1	10.5	10.0	9.2	8.4	7.6	6.7	5.5	3.7						23
12	13.3	12.6	12.1	11.5	10.9	10.0	9.2	8.3	7.3	5.9	4.0						21
13	14.4	13.6	13.1	12.5	11.7	10.8	9.9	9.0	7.9	6.3	4.2						15
14	15.5	14.6	14.1	13.4	12.6	11.6	10.7	9.7	8.5	6.9	4.5						12
15	16.6	15.7	15.1	14.4	13.5	12.4	11.5	10.4	9.1	7.3	4.8						7
16	17.7	16.8	16.2	15.4	14.4	13.2	12.2	11.1	9.7	7.8	5.1						2
17	18.8	17.8	17.2	16.3	15.3	14.0	12.9	11.7	10.3	8.2	5.3						
18	20.0	18.9	18.2	17.3	16.2	14.8	13.6	12.4	10.8	8.6	5.6						1
																	86

80-FOOT TREES.

10	11.2	10.5	10.1	9.6	9.1	8.5	7.9	7.2	6.5	5.7	4.6	3.0					3
11	12.2	11.5	11.1	10.5	10.0	9.3	8.7	8.0	7.2	6.2	5.1	3.3					2
12	13.3	12.6	12.1	11.5	10.9	10.1	9.4	8.7	7.8	6.8	5.5	3.6					6
13	14.4	13.6	13.1	12.5	11.8	10.9	10.1	9.4	8.5	7.4	6.0	3.9					22
14	15.5	14.6	14.1	13.4	12.7	11.8	10.9	10.1	9.1	7.9	6.4	4.3					20
15	16.6	15.7	15.1	14.4	13.5	12.6	11.7	10.9	9.8	8.5	6.8	4.5					12
16	17.7	16.8	16.2	15.4	14.4	13.4	12.5	11.5	10.4	9.1	7.3	4.9					11
17	18.8	17.8	17.2	16.3	15.3	14.2	13.2	12.2	11.0	9.5	7.6	5.1					8
18	20.0	18.9	18.2	17.3	16.1	15.0	14.0	13.0	11.7	10.1	8.1	5.5					5
19	21.1	20.0	19.3	18.3	17.1	15.8	14.7	13.6	12.4	10.7	8.6	5.9					
20	22.3	21.1	20.4	19.2	17.9	16.6	15.5	14.3	12.9	11.1	8.9	6.2					
21	23.4	22.2	21.4	20.2	18.7	17.4	16.2	14.9	13.5	11.7	9.4	6.4					1
22	24.6	23.3	22.5	21.2	19.6	18.2	17.0	15.6	14.0	12.1	9.8	6.7					
																	90

TABLE 49.—*Taper measurements (diameter inside bark) of red spruce in West Virginia*—Continued.

90-FOOT TREES.

[CURVED.]

Diameter breast high.	Height above ground—Feet.																Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	58.05	66.2	74.35	82.5	90.95	98.8	
	Diameter inside bark—Inches.																
Inches.																	*Trees.*
12	13.3	12.6	12.1	11.5	10.9	10.1	9.4	8.8	8.1	7.3	6.4	5.1	3.6				
13	14.4	13.6	13.1	12.5	11.8	11.0	10.3	9.5	8.8	8.0	7.0	5.6	3.9				1
14	15.5	14.6	14.1	13.4	12.8	11.8	11.0	10.3	9.6	8.7	7.5	6.1	4.3				6
15	16.6	15.7	15.1	14.4	13.7	12.6	11.8	11.0	10.2	9.3	8.1	6.5	4.6				6
16	17.7	16.8	16.2	15.4	14.6	13.4	12.6	11.9	11.0	9.9	8.6	7.0	5.0				14
17	18.8	17.8	17.2	16.3	15.5	14.2	13.3	12.5	11.7	10.6	9.2	7.5	5.3				9
18	20.0	18.9	18.2	17.3	16.4	15.1	14.2	13.3	12.4	11.2	9.8	7.9	5.6				4
19	21.1	20.0	19.3	18.3	17.3	16.0	15.0	14.1	13.1	11.9	10.3	8.4	5.9				8
20	22.3	21.1	20.4	19.2	18.1	16.7	15.7	14.8	13.7	12.5	10.9	8.8	6.2				10
21	23.4	22.2	21.4	20.2	19.1	17.6	16.5	15.5	14.4	13.1	11.4	9.3	6.5				5
22	24.6	23.3	22.5	21.2	19.9	18.4	17.4	16.3	15.2	13.7	11.9	9.7	6.8				2
23	25.7	24.4	23.6	22.2	20.9	19.3	18.1	17.0	15.9	14.3	12.4	10.1	7.2				3
24	26.9	25.5	24.6	23.2	21.7	20.0	18.9	17.8	16.5	15.0	13.0	10.6	7.5				
25	28.0	26.6	25.6	24.2	22.6	20.8	19.7	18.6	17.2	15.6	13.5	11.0	7.7				
26	29.2	27.7	26.7	25.2	23.5	21.6	20.4	19.2	17.9	16.3	14.1	11.4	8.1				
																	68

100-FOOT TREES.

14	15.5	14.6	14.1	13.4	12.7	11.8	11.0	10.3	9.8	9.2	8.3	7.2	5.9	4.2	2.2		
15	16.6	15.7	15.1	14.4	13.6	12.6	11.8	11.2	10.5	9.7	8.9	7.8	6.4	4.5	2.4		4
16	17.7	16.8	16.2	15.4	14.6	13.4	12.6	11.9	11.2	10.5	9.6	8.3	6.8	4.9	2.6		3
17	18.8	17.8	17.2	16.3	15.5	14.3	13.4	12.6	12.0	11.2	10.2	8.8	7.1	5.2	2.8		5
18	20.0	18.9	18.2	17.3	16.3	15.1	14.2	13.4	12.7	11.9	10.8	9.4	7.7	5.6	3.1		12
19	21.1	20.0	19.3	18.3	17.2	15.9	15.0	14.2	13.5	12.6	11.4	10.0	8.1	5.9	3.3		5
20	22.3	21.1	20.4	19.2	18.2	16.8	15.8	15.0	14.3	13.2	12.0	10.5	8.6	6.2	3.4		10
21	23.4	22.2	21.4	20.2	19.1	17.7	16.7	15.8	15.0	13.9	12.7	11.1	9.0	6.6	3.7		12
22	24.6	23.3	22.5	21.2	20.0	18.5	17.5	16.6	15.7	14.6	13.2	11.6	9.5	7.0	3.9		11
23	25.7	24.4	23.6	22.2	21.0	19.4	18.4	17.4	16.4	15.3	13.9	12.1	9.9	7.3	4.1		5
24	26.9	25.5	24.6	23.2	21.8	20.3	19.1	18.2	17.2	15.9	14.5	12.6	10.4	7.7	4.4		1
25	28.0	26.6	25.6	24.2	22.8	21.0	19.9	18.9	17.8	16.6	15.1	13.2	10.8	8.0	4.6		3
26	29.2	27.7	26.7	25.2	23.6	21.9	20.7	19.7	18.6	17.3	15.8	13.8	11.3	8.4	4.9		
27	30.4	28.8	27.7	26.2	24.5	22.7	21.4	20.4	19.2	17.9	16.3	14.3	11.8	8.8	5.1		1
28	31.5	29.9	28.8	27.2	25.4	23.5	22.2	21.1	19.9	18.5	16.9	14.8	12.3	9.1	5.3		
29	32.7	31.0	29.9	28.2	26.3	24.4	23.1	21.9	20.6	19.2	17.4	15.3	12.8	9.5	5.5		
30	33.9	32.2	31.0	29.2	27.2	25.2	23.8	22.5	21.3	19.8	18.1	15.9	13.2	9.9	5.8		
31	35.1	33.3	32.0	30.1	28.1	26.0	24.6	23.3	22.0	20.5	18.6	16.4	13.6	10.2	6.0		1
32	36.3	34.4	33.1	31.1	29.0	26.8	25.3	24.0	22.6	21.1	19.2	16.9	14.1	10.7	6.3		
33	37.6	35.5	34.2	32.1	30.0	27.6	26.2	24.8	23.4	21.8	19.8	17.5	14.6	11.1	6.6		1
34	38.8	36.6	35.2	33.1	30.9	28.4	27.0	25.5	24.0	22.4	20.4	17.9	15.1	11.5	6.8		
																	74

110-FOOT TREES.

16	17.7	16.8	16.2	15.4	14.5	13.4	12.6	12.0	11.5	11.0	10.4	9.4	8.0	6.4	4.7	2.7	
17	18.8	17.8	17.2	16.3	15.4	14.3	13.4	12.8	12.2	11.7	11.0	9.9	8.5	6.8	5.0	2.8	1
18	20.0	18.9	18.2	17.3	16.3	15.1	14.2	13.6	13.1	12.4	11.7	10.5	9.0	7.3	5.3	3.1	2
19	21.1	20.0	19.3	18.3	17.3	15.9	15.0	14.4	13.8	13.2	12.3	11.0	9.5	7.6	5.5	3.3	3
20	22.3	21.1	20.4	19.2	18.2	16.8	15.9	15.2	14.6	13.8	12.9	11.6	10.0	8.0	5.8	3.4	2
21	23.4	22.2	21.4	20.2	19.2	17.7	16.7	16.1	15.4	14.6	13.6	12.2	10.5	8.4	6.2	3.6	
22	24.6	23.3	22.5	21.2	20.1	18.6	17.6	16.8	16.1	15.3	14.3	12.8	11.0	8.9	6.5	3.8	5
23	25.7	24.4	23.6	22.2	21.1	19.5	18.5	17.6	16.9	16.1	15.0	13.4	11.5	9.3	6.8	4.0	7
24	26.9	25.5	24.6	23.2	21.9	20.4	19.3	18.5	17.7	16.7	15.6	14.0	12.1	9.8	7.2	4.2	5
25	28.0	26.6	25.6	24.2	22.9	21.3	20.2	19.3	18.5	17.5	16.2	14.6	12.6	10.2	7.4	4.4	5
26	29.2	27.7	26.7	25.2	23.9	22.2	21.0	20.1	19.2	18.2	16.9	15.2	13.1	10.6	7.8	4.6	4
27	30.4	28.8	27.7	26.2	24.8	23.1	21.9	20.9	19.9	18.8	17.5	15.8	13.7	11.1	8.1	4.8	4
28	31.5	29.9	28.8	27.2	25.8	24.0	22.8	21.7	20.7	19.6	18.2	16.4	14.2	11.6	8.5	5.0	6
29	32.7	31.0	29.9	28.2	26.7	24.9	23.7	22.6	21.5	20.3	18.8	16.9	14.7	12.0	8.9	5.2	3
30	33.9	32.2	31.0	29.2	27.6	25.9	24.6	23.4	22.2	20.9	19.4	17.6	15.3	12.5	9.2	5.4	1
31	35.1	33.3	32.0	30.1	28.6	26.8	25.4	24.2	23.0	21.7	20.1	18.1	15.7	12.9	9.6	5.6	1
32	36.3	34.4	33.1	31.1	29.6	27.7	26.3	25.0	23.8	22.4	20.7	18.7	16.3	13.4	9.8	5.8	
33	37.6	35.5	34.2	32.1	30.6	28.7	27.2	25.9	24.6	23.1	21.4	19.3	16.9	13.9	10.2	6.0	
34	38.8	36.6	35.2	33.1	31.5	29.6	28.1	26.9	25.3	23.8	22.0	20.0	17.5	14.4	10.5	6.1	
35	40.0	37.7	36.3	34.1	32.4	30.5	29.0	27.7	26.1	24.5	22.6	20.5	18.0	14.8	10.7	6.3	
36	41.2	38.8	37.4	35.1	33.4	31.4	29.8	28.3	26.9	25.2	23.3	21.2	18.6	15.3	10.9	6.5	
																	49

Data collected by John Foley in Greenbrier County, 1903.

STAND TABLES.

Tables 50 to 53 are all stand tables for the spruce slope type and serve as a rough basis for comparison between the four States within which the red spruce principally occurs. The principal associates are balsam, yellow birch, beech, hemlock, sugar maple, and red maple, with incidental arborvitæ, white pine, and numerous hardwoods. These vary much from one place to another.

TABLE 50.—*Stand of spruce and associates on spruce slope type in Maine—Average stand for 20 acres, culled.*[1]

[Data collected by R. S. Hosmer in Squaw Mountain Township in 1902.]

Diameter breast high.	Number of trees per acre.			Other species.
	Spruce.	Other species.	Total.	
Inches.				*Per cent.*
1	67.90	26.55	94.45	28
2	63.65	27.40	91.05	30
3	47.25	20.40	67.65	30
4	31.05	13.00	44.05	30
5	20.40	9.25	29.65	31
6	16.20	6.95	23.15	30
7	12.65	4.35	17.00	26
8	9.70	3.85	13.55	28
9	5.75	2.40	8.15	29
10	5.10	2.35	7.45	32
11	2.55	1.95	4.50	43
12	3.05	1.20	4.25	28
13	2.15	.95	3.10	31
14	1.15	1.40	2.55	55
15	1.40	.90	2.30	39
16	1.35	.65	2.00	32
17	.85	.40	1.25	32
18	.60	.40	1.00	40
19	.70	.40	1.10	36
20	.30	.40	.70	57
21	.15	.20	.35	57
22	.15	.35	.50	70
23	.15	.10	.25	40
24	.05	.25	.30	83
25	.....	.05	.05	100
26	.....	.05	.05	100
27	.....	.....	.....	.....
28	.....	.....	.....	.....
29	.....	.05	.05	100
30	.....	.05	.05	100
31	.....	.....	.....	.....
32	.....	.05	.05	100
Total	294.25	126.30	420.55	30
Trees 10 inches and over	19.70	12.15	31.85	38
Trees 12 inches and over	12.05	7.85	19.90	39
	Sq. ft.	*Sq. ft.*	*Sq. ft.*	*Per cent.*
Total basal area	41.5	23.6	65.1	36
Trees 10 inches and over	19.5	14.5	34.0	43
Trees 12 inches and over	15.0	11.9	26.9	44

[1] Culled 30 years before, removing trees with a total basal area of 4.2 square feet; culled 5 years before, removing trees with a total basal area of 33.3 square feet; culled 1 year before, removing trees with a total basal area of 16.5 square feet.

TABLE 51.—*Stand of spruce and associates on spruce slope type in New Hampshire—Average stand for 65 acres.*

[Data collected by A. K. Chittenden in Waterville Township in 1903.]

Diameter breast high.	Number of trees per acre.			Other species.
	Spruce.	Other species.	Total.	
Inches.				*Per cent.*
2	22.20	19.96	42.16	47
3	15.51	12.01	27.52	44
4	14.28	12.08	26.36	46
5	12.94	10.59	23.53	45
6	11.20	8.21	19.41	42
7	10.48	6.76	17.24	39
8	10.45	6.83	17.28	40
9	11.14	5.18	16.32	32
10	11.03	5.39	16.42	33
11	10.29	3.57	13.86	26
12	10.38	3.08	13.46	23
13	9.12	2.64	11.76	22
14	9.22	2.44	11.66	21
15	7.52	1.91	9.43	20
16	7.89	1.62	9.51	17
17	5.80	1.21	7.01	17
18	5.12	1.11	6.23	18
19	3.40	.90	4.30	21
20	2.48	.95	3.43	28
21	2.34	.84	3.18	26
22	1.18	.66	1.84	36
23	.68	.31	.99	31
24	.45	.28	.73	38
25	.29	.18	.47	38
26	.11	.23	.34	68
27	.15	.12	.27	44
28	.09	.04	.13	31
29	.....	.05	.05	100
30	.....	.05	.05	100
31	.....	.02	.02	100
32	.....	.....	.....	.....
33	.....	.02	.02	100
34	.....	.02	.02	100
35	.....	.02	.02	100
Total	195.74	109.28	305.02	36
Trees 10 inches and over	87.54	27.66	115.20	24
Trees 12 inches and over	66.22	18.70	84.92	22
	Sq. ft.	*Sq. ft.*	*Sq. ft.*	*Per cent.*
Total basal area	122.1	45.3	167.4	27
Trees 10 inches and over	104.2	33.7	137.9	24
Trees 12 inches and over	91.4	28.4	119.8	24

TABLE 52.—*Stand of spruce and associates on spruce slope type in New York—Average stand for 37 acres.*

[Data collected by R. S. Hosmer in Township 40, Hamilton County, in 1900.]

Diameter breast high.	Number of trees per acre.			Other species.
	Spruce.	Other species.	Total.	
Inches.				*Per cent.*
5	12.35	0.95	13.30	7
6	9.35	.46	9.81	5
7	7.86	.22	8.08	3
8	6.57	.14	6.71	2
9	6.24	.22	6.46	3
10	5.05	.32	5.37	6
11	4.57	.19	4.76	4
12	3.81	2.23	6.04	37
13	3.41	1.53	4.94	31
14	3.35	1.92	5.27	36
15	2.22	1.61	3.83	42
16	2.03	1.46	3.49	42
17	1.65	1.20	2.85	42
18	1.19	1.05	2.24	47
19	.84	1.03	1.87	55
20	.70	.87	1.57	55
21	.32	.89	1.21	74
22	.19	.59	.78	76
23	.08	.70	.78	90
24	.08	.54	.62	87
25	.03	.38	.41	93
26	.....	.41	.41	100
27	.05	.21	.26	81
28	.....	.16	.16	100
29	.....	.22	.22	100
30	.....	.05	.05	100
31	.....	.03	.03	100
32	.....	.03	.03	100
33	.....	.03	.03	100
34	.....	.03	.03	100
Total	71.94	19.67	91.61	21
Trees 10 inches and over	29.57	17.68	47.25	37
Trees 12 inches and over	19.95	17.17	37.12	46
	Sq. ft.	*Sq. ft.*	*Sq. ft.*	*Per cent.*
Total basal area	41.6	31.3	72.9	43
Trees 10 inches and over	31.0	30.9	61.9	50
Trees 12 inches and over	25.2	30.6	55.8	55

TABLE 53.—*Stand of spruce and associates on spruce slope type in West Virginia—Average stand for 100 acres.*

[Data collected by John Foley in Greenbrier County in 1902.]

Diameter breast high.	Number of trees per acre.			Other species.
	Spruce.	Other species.	Total.	
Inches.				*Per cent.*
1	17.05	11.06	28.11	39
2	18.92	12.19	31.11	39
3	20.44	10.95	31.39	35
4	14.01	8.22	22.23	37
5	9.01	6.70	15.71	43
6	6.03	4.94	10.97	45
7	5.19	3.87	9.06	43
8	4.24	3.17	7.41	43
9	2.95	2.36	5.31	44
10	2.79	2.49	5.28	47
11	1.93	1.51	3.44	44
12	1.71	1.59	3.30	48
13	1.56	1.35	2.91	46
14	1.55	1.36	2.91	47
15	1.35	1.27	2.62	48
16	1.20	.95	2.15	44
17	1.10	.99	2.09	47
18	1.17	.83	2.00	41
19	.84	.84	1.68	50
20	.88	.81	1.69	48
21	.85	.76	1.61	47
22	.73	.56	1.29	47
23	.44	.65	1.09	60
24	.56	.65	1.21	54
25	.55	.39	.94	41
26	.33	.37	.70	53
27	.38	.36	.74	49
28	.27	.41	.68	60
29	.11	.28	.39	72
30	.23	.23	.46	50
31	.12	.24	.36	67
32	.04	.28	.32	87
33	.10	.09	.19	47
34	.03	.27	.30	90
35	.03	.15	.18	83
36	.02	.08	.10	80
37	.....	.03	.03	100
38	.....	.08	.08	100
39	.....	.01	.01	100
40	.....	.01	.01	100
41	.....	.01	.01	100
42	.....	.02	.02	100
Total stand	118.71	83.38	202.09	41
Trees 10 inches and over	20.87	19.92	40.79	49
Trees 12 inches and over	16.15	15.92	32.07	50
	Sq. ft.	*Sq. ft.*	*Sq. ft.*	*Per cent.*
Total basal area	43.6	45.7	89.3	51
Trees 10 inches and over	34.3	39.1	73.4	53
Trees 12 inches and over	31.5	36.7	68.2	54

Table 54 gives in summary form the sample plot data used as a basis for the "second-growth" spruce yield table (Table 17).

TABLE 54.—*Summary of spruce sample plot data used as a basis for the second-growth or "old-field" yield table (Table 17).*

Plot No.	Age.	Quality.[1]	Trees per acre.[2]					Basal area.[2]				Average diameter breast high.[2]				Average height dominant and intermediate	Yield (from dominant and intermediate trees only).[3]			Area.	Location.
			All green.	Green 6 inches and over.	Dominant.	Dominant and intermediate.	Dead.	All green.	Green 6 inches and over.	Dominant.	Dominant and intermediate.	All green.	Green 6 inches and over.	Dominant.	Dominant and intermediate.						
	Yrs.							*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Feet.*	*Bd. feet.*	*Cu. ft.*	*Cords.*	*Acres.*	
1	75	II	810	683	455	597	71	283.50	265.58	208.82	243.53	8.0	8.4	9.2	8.6	60	29,346	6,616	67.5	0.07	Lincoln (Brown Lot), Me.
2	70	II	650	590	400	580	30	260.60	252.70	203.90	250.70	8.6	8.9	9.7	8.9	56	31,530	6,619	67.5	.1	E. Winn (Crocker Lot), Me.
3	66	II	728	625	380	558	255	246.53	234.95	171.85	216.45	7.9	8.3	9.1	8.4	54	25,261	5,562	56.2	.4	E. Millinocket (Freeman Powers Lot), Me.
4	68	III	763	503	390	550	297	209.47	183.43	158.90	188.17	7.1	8.2	8.6	7.9	53	18,663	4,583	43.3	.3	Bethel (Porter Farwell Lot), Me.
5	71	III	1,111	698	444	751	493	259.20	210.98	153.78	213.51	6.5	7.4	8.0	7.2	52	19,387	5,197	48.2	.225	Magolloway Settlement (Brown Farm), Me.
6	72	III	976	714	442	672	460	256.34	225.22	162.32	211.60	6.9	7.6	8.2	7.6	51	20,810	5,050	49.5	.5	Do.
7	68	II	830	665	405	620	570	261.25	240.80	173.05	224.95	7.6	8.1	8.9	8.2	59	26,710	5,983	59.3	.2	Do.
8	71	III	1,005 1,010	660 665	440	660	780 785	237.80 241.10	194.65 197.95	146.80	189.35	6.6	7.4	7.8	7.3	53	17,395	4,668	43.8	.2	Do.
9	67	I	1,050	820	620	920	680	285.30	256.60	215.20	268.30	7.1	7.6	8.0	7.3	55	24,730	6,586	61.3	.1	Magolloway Settlement (Kimball Pasture), Me.
10	68	I	825	675	505	660	320	279.15	260.60	218.35	254.70	7.9	8.4	8.9	8.4	59	31,020	6,742	67.7	.2	Dummer (Pontook Dam Lot), N. H.
11	62	III	1,116	656	480	776	436	230.20	176.76	139.64	188.48	6.2	7.0	7.3	6.7	48	12,224	4,045	34.6	.25	West Milan, N. H.
12	61	I	627 637	557 560	383	498	90 100	253.67 255.34	244.37 245.27	195.30	227.67	8.6	9.0	9.7	9.2	58	29,217	6,054	61.2	.3	Dummer (Pontook Dam Lot), N. H.
13	68	II	540	520	335	460	60	230.34	227.87	169.67	213.34	8.8	9.0	9.7	9.2	52	25,630	5,246	52.9	.15	West Milan (Nay Lot), N. H.
14	23	I	3,017	33	3,017	3,017	17	129.00	6.67	129.00	129.00	2.8	6.0	2.8	2.8	22	.....	.....	.....	.06	Stark, N. H.
15	33	II	1,820 2,760	200	1,540	1,820	 940	181.00 198.60	40.00	169.00	181.00	4.3 3.6	6.0	4.5	4.3	27	.....	.....	.....	.05	Stark (Potter Lot), N. H.

16	52	II	{ 820 / 850	515 / 525	280	465	{ 525 / 555	201.50 / 206.35	164.90 / 168.10	107.20	146.30	6.7	7.7	8.4	7.6	51	14,150	3,432	32.8	.2	{ Stark (Widows' Lot), N. H.
17	51	I	860	620	400	460	780	270.60	243.60	191.00	204.40	7.6	8.5	9.4	9.0	56	27,000	5,636	57.2	.05	Do.
18	46	I	{ 526 / 549	440 / 447	293	410	{ 117 / 140	187.90 / 192.97	178.73 / 182.77	139.87	170.57	{ 8.1 / 8.0	8.6 / 8.7	9.4	8.7	54	20,154	4,272	42.3	.3	{ Stark (Nash Stream Lot), N. H.
19	73	II	740	620	440	593	800	223.20	207.73	168.00	199.40	7.4	7.8	8.4	7.8	61	22,766	5,565	54.1	.15	Groton (Hall Lot), Vt.
20	54	II	{ 1,260 / 1,267	667	540	887	{ 900 / 907	251.80 / 252.13	188.53	161.87	213.33	{ 6.1 / 6.0	7.2	7.4	6.6	48	15,100	4,690	39.9	.15	Do.
21	62	III	1,527	640	540	767	1,067	268.33	182.87	159.87	195.93	5.7	7.2	7.4	6.8	47	14,107	4,268	37.5	.15	Glencliff (Sanitarium Lot), N. H.
22	50	III	2,310	620	810	1,320	2,720	302.90	147.50	173.50	233.50	4.9	6.6	6.3	5.7	46	7,770	4,312	28.4	.1	Glencliff (Pike Tract), N. H.
23	62	I	1,270	940	600	990	420	304.30	268.40	197.60	274.20	6.6	7.2	7.8	7.1	50	20,750	6,256	57.1	.1	Do.
24	71	III	1,296	776	644	1,004	960	266.16	206.20	178.00	236.52	6.1	7.0	7.1	6.6	47	14,232	4,806	40.8	.25	Pike (Club House Tract), N. H.
25	61	III	1,265	745	530	905	555	264.95	206.85	161.40	225.40	6.2	7.1	7.5	6.8	46	15,335	4,692	41.2	.2	Do.
26	53	II	1,408	668	548	924	672	254.88	173.96	148.96	207.96	5.8	6.9	7.1	6.4	47	11,316	4,344	35.3	.25	Grantham (Green Lot), N. H.
27	67	II	792	652	368	592	704	231.88	213.28	147.36	198.92	7.3	7.7	8.6	7.8	62	24,256	5,765	58.1	.25	Grantham (Draper Lot), N. H.
28	75	III	788	584	404	584	368	204.92	179.24	140.64	174.64	6.9	7.5	8.0	7.4	46	16,220	3,875	36.7	.25	Do.
29	64	I	835	720	455	675	365	269.15	255.30	193.80	242.00	7.7	8.1	8.8	8.1	57	27,975	6,328	63.2	.2	Do.
30	77	II	560	516	336	448	324	242.36	237.00	192.64	221.72	8.9	9.2	10.3	9.5	62	30,612	6,371	63.4	.25	Do.
31	57	II	896	610	453	656	180	224.66	195.50	161.37	200.63	6.8	7.7	8.1	7.5	47	18,351	4,521	43.2	.3	Grantham (Green Lot), N. H.
32	62	III	1,140	608	492	820	1,216	224.20	165.56	142.12	194.56	6.0	7.1	7.3	6.6	51	12,968	4,456	35.7	.25	Grantham (Corbin Park), N. H.
33	80	III	1,234	773	617	904	1,310	286.74	229.17	196.00	243.87	6.5	7.4	7.6	7.0	51	19,373	5,551	50.0	.3	Do.
34	51	II	1,320	640	540	880	1,620	255.20	181.40	160.20	211.80	6.0	7.2	7.4	6.6	48	13,660	4,488	37.6	.05	Plainfield (Corbin Park), N. H.
35	71	II	895	690	460	680	770	251.10	227.70	176.45	222.10	7.2	7.8	8.4	7.7	54	23,195	5,474	53.2	.2	Do.
36	63	I	725	585	370	530	350	253.70	238.70	185.55	227.00	8.0	8.6	9.6	8.9	54	26,850	4,764	58.0	.2	Cornish (?) (Corbin Park), N. H.
37	69	II	1,216	872	688	1,064	1,520	275.60	233.76	196.40	259.84	6.4	7.0	7.2	6.7	53	18,176	6,037	51.8	.125	Do.
38	66	II	753	690	413	613	223	276.36	268.83	197.90	249.93	8.2	8.5	9.4	8.6	54	29,283	6,281	63.2	.3	Do.
39	63	II	1,290	810	545	925	1,000	297.05	239.70	182.85	253.80	6.5	7.4	7.8	7.1	56	22,850	6,413	58.8	.2	Do.
40	50	I	1,190	760	640	940	325	261.75	210.90	186.00	234.95	6.4	7.1	7.3	6.8	53	16,460	5,339	45.7	.2	Bridgewater (Macawes Club Lot), Vt.
41	69	II	803	682	425	613	443	257.43	241.88	182.15	226.83	7.7	8.1	8.9	8.2	53	24,908	5,592	55.8	.4	Bridgewater (Furman Lot), Vt.
42	58	I	1,272	856	576	860	856	305.92	255.20	196.96	252.60	6.6	7.4	7.9	7.3	51	21,688	5,851	54.9	.25	Do.
43	58	I	885	695	515	700	535	256.55	231.05	193.50	230.85	7.3	7.8	8.3	7.8	52	22,640	5,509	53.1	.2	Do.
44	50	III	1,650	590	520	1,000	1,040	252.10	143.90	130.70	196.70	5.3	6.7	6.7	6.0	47	7,690	4,061	27.9	.1	Springfield (Baker & Bailey Lot), N. H.

[1] The site quality was first determined separately on the basis of total basal area, of average height, of average breast-high diameter, and of volume in board feet, in cubic feet, and in cords and the plot finally assigned to that quality with which it was most commonly identified.

[2] The plots which have the double figures have their "suppressed and dead" trees inadvertently tallied together. The smaller of the two figures assumes that all the trees so tallied were dead; the larger figure that all were suppressed.

[3] The top diameter limits for these measurements were the same as those indicated in footnotes 3, 4, and 5, Table 17, page —. The yield of plots less than 40 years old was not calculated.

The data on plots 1 to 51 were collected in 1910 by E. D. Fletcher and the author. The remaining 8 plots are permanent sample plots previously established by the Forest Service and remeasured in 1911 by W. D. Sterrett in collaboration with the author.

TABLE 54.—*Summary of spruce sample plot data used as a basis for the second-growth or "old-field" yield table (Table 17)*—Continued.

Plot No.	Age.	Quality.[1]	Trees per acre.[2]					Basal area.[2]				Average diameter breast high.[2]				Average height dominant and intermediate.	Yield (from dominant and intermediate trees only).[3]			Area.	Location.
			All green.	Green 6 inches and over.	Dominant.	Dominant and intermediate.	Dead.	All green.	Green 6 inches and over.	Dominant.	Dominant and intermediate.	All green.	Green 6 inches and over.	Dominant.	Dominant and intermediate.						
	Yrs.							*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Feet.*	*Bd. feet.*	*Cu. ft.*	*Cords.*	*Acres.*	
45	57	II	960	627	507	747	400	219.73	182.73	158.27	199.13	6.5	7.3	7.6	7.0	51	15,534	4,873	39.9	.15	Groton (Hood Lot), N. H.
46	67	II	553	473	380	480	60	232.20	222.47	200.00	223.00	8.8	9.3	9.8	9.2	54	27,340	5,763	57.8	.15	Woodstock, Vt.
47	64	I	810	670	427	640	253	273.03	258.03	199.43	249.40	7.9	8.4	9.3	8.5	61	31,270	6,931	69.4	.3	Do.
48	69	II	673	563	423	536	333	232.37	218.13	186.17	210.87	8.0	8.4	9.0	8.5	60	26,687	5,777	58.2	.3	Reading, Vt.
49	70	II	785	665	450	625	160	245.65	229.45	177.15	220.00	7.6	8.0	8.5	8.0	57	24,725	5,716	56.8	.2	Do.
50	65	I	725	610	475	575	190	268.65	255.70	223.25	247.60	8.2	8.8	9.3	8.9	60	31,560	6,691	67.7	.2	Do.
51	95	III	740	680	475	600	500	252.90	244.50	199.60	227.20	7.9	8.1	8.8	8.3	56	25,815	5,782	58.0	.2	Do.
P.S.P. 1	65	II	486	392	382	418	68	209.00	199.84	196.12	201.86	8.9	9.7	9.7	9.4	57	24,740	5,036	52.0	.5	Corbin Park, N. H.
P.S.P. 2	65	II	762	610	590	696	102	243.04	224.72	218.74	236.10	7.6	8.2	8.2	7.9	54	24,510	5,823	56.2	.5	Do.
P.S.P. 4	65	III	574	452	452	520	62	187.90	174.72	173.38	183.16	7.7	8.4	8.4	8.0	54	20,242	4,567	44.9	.5	Do.
P.S.P. 6	65	III	414	322	306	358	14	155.36	147.28	143.18	151.34	8.3	9.2	9.3	8.8	56	18,026	3,922	38.8	.5	Do.
P.S.P.17	65	II	250	240	240	240	.....	161.60	160.20	160.20	160.20	10.9	11.1	11.1	11.1	69	26,180	4,980	51.4	.1	Do.
P.S.P.18	65	II	680	610	480	620	.....	231.50	222.20	193.50	221.30	7.9	8.2	8.6	8.1	62	33,930	6,125	61.2	.1	Do.
P.S.P.20	55	II	795	645	645	745	.....	215.25	197.90	195.45	210.65	7.0	7.5	7.5	7.2	54	18,845	5,119	48.1	.2	Do.
P.S.P.21	55	II	1,155	795	775	950	.....	269.65	228.05	220.10	246.90	6.5	7.3	7.2	6.9	53	20,640	5,840	53.4	.2	Do.

[1] The site quality was first determined separately on the basis of total basal area, of average height, of average breast-high diameter, and of volume in board feet, in cubic feet and in cords and the plot finally assigned to that quality with which it was most commonly identified.

[2] The plots which have the double figures have their "suppressed and dead" trees inadvertently tallied together. The smaller of the two figures assumes that all the trees so tallied were dead; the larger figure that all were suppressed.

[3] The top diameter limits for these measurements were the same as those indicated in footnotes 3, 4, and 5, Table 17, page —. The yield of plots less than 40 years old was not calculated.

The data on plots 1 to 51 were collected in 1910 by E. D. Fletcher and the author. The remaining 8 plots are permanent sample plots previously established by the Forest Service and remeasured in 1911 by W. D. Sterrett in collaboration with the author.

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